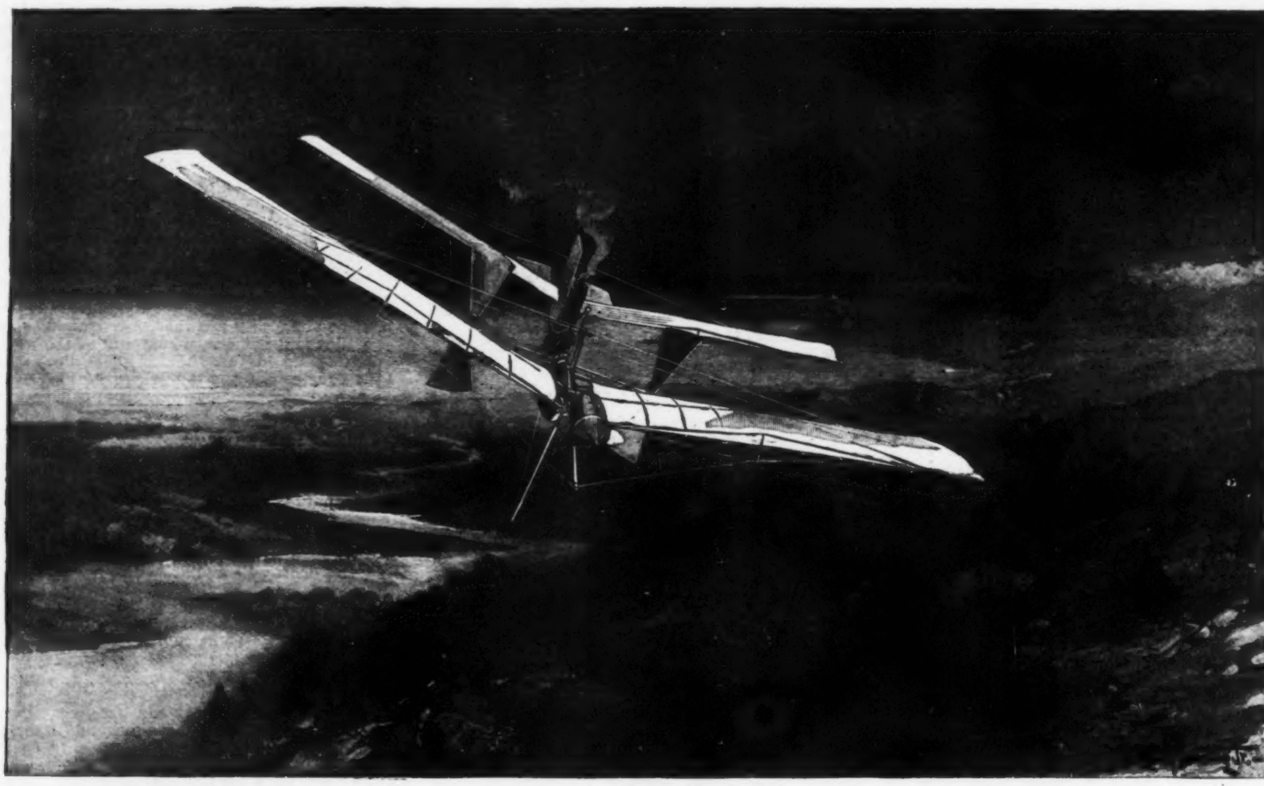
SCIENTIFIC AMERICAN SUPPLEMENT. No 1404

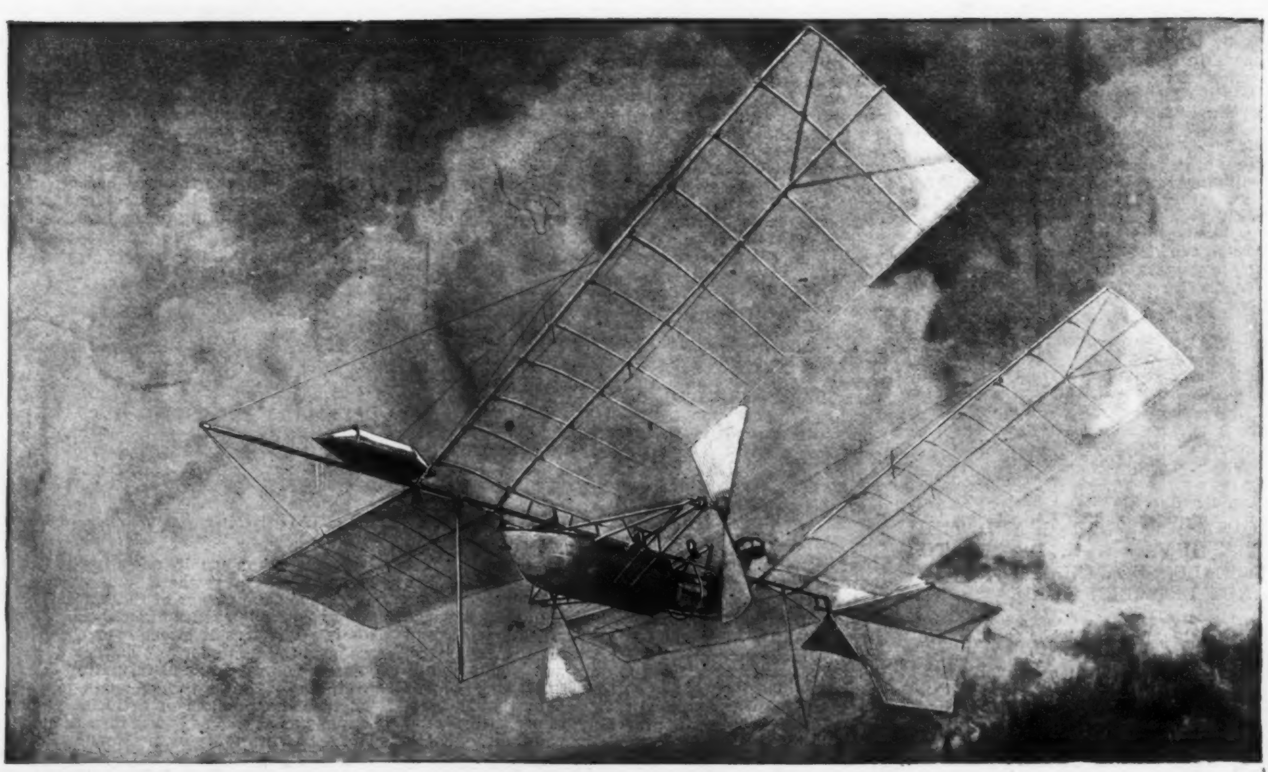
Scientific American, established 1845.
Scientific American Supplement. Vol. LIV. No. 1404

NEW YORK, NOVEMBER 29, 1902.

Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.



THE AERODROME AS SEEN FROM ABOVE.



THE AERODROME AS SEEN FROM BELOW.

THE LANGLEY AERODROME IN FLIGHT.

THE LANGLEY AERODROME.*

I. NOTE PREPARED FOR THE CONVERSAZIONE OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, NEW YORK CITY, APRIL 12, 1901.

What is popularly known as the "flying machine" is literally a machine, without gas to support it, in no way resembling a balloon, and which its inventor has called the aërodrome (signifying "air runner"). The aërodrome is, then, the name given to this apparatus by Mr. Langley to indicate the principle of its action, which in no way resembles that of a balloon that floats, because it is lighter than the air, while the aërodrome is hundreds of times heavier than the air. The weighty machine owes its support to another principle—that is, to the *rapidity* with which it runs over the air, like a skater on thin ice. The balloon in a calm remains indefinitely suspended over one spot. This machine, built almost entirely of steel, is far heavier in relation to the air than a ship of solid lead would be in relation to the water, and could not remain in the air if still.

The essence of its action, then, is in its motion, without which it could not remain suspended. It is moved rapidly by a steam engine, carrying its own fuel and its water supply, by which it can be kept up indefinitely, while it is also, and by the necessity of its own action, rapidly advancing.

This may all be admitted as probably true in theory, but it is not generally known that this has actually been done.

The two large photographs are each about one-third the full size of one of several working models,† each of which is driven by a steam engine of over 1¼ horse power. This and other like models have repeatedly flown distances of over half a mile, at a speed of from 20 to 30 miles an hour.

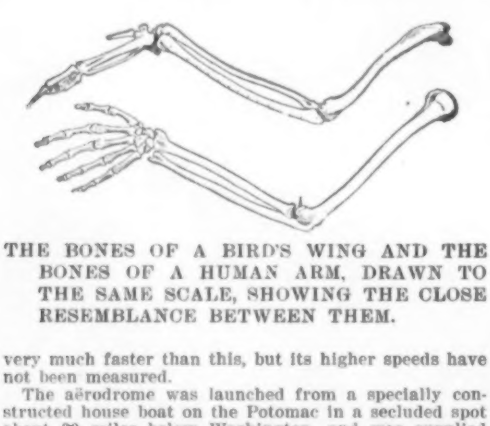
This actual result has not been advertised, and is comparatively little known, though these models are believed to have done something absolutely new in the history of the world. They are the product of a great many years of assiduous labor, and represent the condition of the experiments in Mr. Langley's hands up to the close of the year 1896, since which time he has made no public statement of his work, which is understood to be still going on in connection with experiments for the War Department in demonstrating the possible uses of the future aërodrome as an engine of war.

Reverting to the present models, they represent a machine whose weight is about 30 pounds, one-fourth of which is contained in the engine and machinery, which is of unexampled lightness. Within the small body, seen in the photograph suspended under the main rod, is contained everything for generating 1¼ (brake) horse power, the total weight of fire grate, boiler, and every accessory being less than 7 pounds. The engine, with its cylinders, pistons, and every moving part, weighs 26 ounces. This puts in motion the propellers, which, turning at a rate of between 800 and 1,200 revolutions per minute, drives the aërodrome at a speed which varies greatly, according to the inclination given to the motionless "wings."

Mr. Langley, after a great many years of preliminary experiment on supporting surfaces, which he has described in his "Experiments in Aërodynamics," first made a remarkable, and to the engineer, most paradoxical statement; namely, that in such aërial navigation as was there shown to be possible, under certain definite conditions the power required would in theory *diminish* indefinitely as the speed increased, and that it would actually diminish in practice up to a certain limit.

This statement, which has since been called "Langley's law," is justified in practice, but the conditions which give this increase of speed with decrease of power are limited by others which demand that the flight should be made in safety and without that danger of accident which might come in applying rigorously exact theoretical conclusions without regard to the security of the flight. The actual speed which was obtained, then, was under conditions where security was chiefly sought.

In the experiments which have hitherto been made, safety has accordingly been the first consideration, and the "wings," or rather the motionless supporting surfaces, have been given such an inclination as to cause the speed to be limited to between 20 and 30 miles an hour. The machine has actually traveled



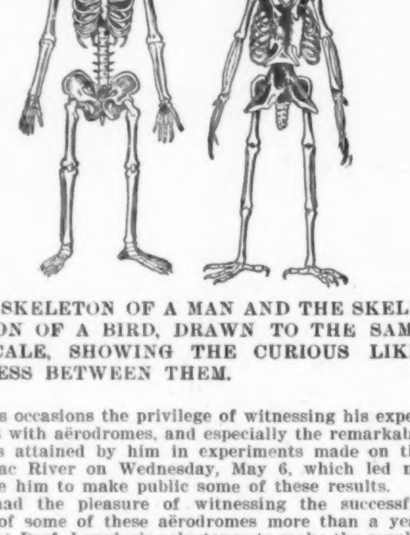
THE BONES OF A BIRD'S WING AND THE BONES OF A HUMAN ARM, DRAWN TO THE SAME SCALE, SHOWING THE CLOSE RESEMBLANCE BETWEEN THEM.

very much faster than this, but its higher speeds have not been measured.

The aërodrome was launched from a specially constructed house boat on the Potomac in a secluded spot about 30 miles below Washington, and was supplied with water for a short course lest it should, in its uncontrolled flight, go altogether out of reach, and lose itself in the neighboring Virginia forests. The idea of making the flight over water from a house boat or raft may appear obvious when once stated, but like many simple results it was only reached after long experiment with other methods, and its utility has since been shown by its employment by others. There was no other reason why it should not fly for an indefinite time except the waste of water, which in the model had no provision for its renewal by condensation. The aërodrome, which is one of several which have flown considerable distances, performed this first flight on May 6, 1896, at a private trial of which Dr. Alexander Graham Bell was the only witness. His contemporary statement may be found in the Comptes Rendus of the French Institute, cxxii, May 26, 1896.

A similar statement by him in the pages of Nature, May 28, 1896, vol. 54, is as follows:

"Through the courtesy of Mr. S. P. Langley, Secretary of the Smithsonian Institution, I have had on



THE SKELETON OF A MAN AND THE SKELETON OF A BIRD, DRAWN TO THE SAME SCALE, SHOWING THE CURIOUS LIKENESS BETWEEN THEM.

various occasions the privilege of witnessing his experiments with aërodromes, and especially the remarkable success attained by him in experiments made on the Potomac River on Wednesday, May 6, which led me to urge him to make public some of these results.

"I had the pleasure of witnessing the successful flight of some of these aërodromes more than a year ago, but Prof. Langley's reluctance to make the results public at that time prevented me from asking him, as I have done since, to let me give an account of what I saw.

"On the date named two ascensions were made by the aërodrome, or so-called "flying machine," which I will not describe here further than to say that it appeared to me to be built almost entirely of metal and driven

PENAUD'S FLYING TOY (ONE-EIGHTH OF ACTUAL SIZE).

by a steam engine, which I have understood was carrying fuel and a water supply for a very brief period, and which was of extraordinary lightness.

"The absolute weight of the aërodrome, including that of the engine and all appurtenances, was, as I was told, about 25 pounds, and the distance from tip to tip of the supporting surfaces was, as I observed, about 12 or 14 feet.

"The method of propulsion was by aërial screw propellers, and there was no gas or other aid for lifting it in the air except its own internal energy.

"On the occasion referred to the aërodrome at a given signal started from a platform about 20 feet above the water and rose at first directly in the face of the wind, moving at all times with remarkable steadiness, and subsequently swinging around in large curves of perhaps a hundred yards in diameter, and continually ascending until its steam was exhausted, when, at a lapse of about a minute and a half and at a height which I judged to be between 80 and 100 feet in the air, the wheels ceased turning, and the machine, deprived of the aid of its propellers, to my surprise did not fall, but settled down so softly and gently that it touched the water without the least shock, and was in fact immediately ready for another trial.

"In the second trial, which followed directly, it repeated in nearly every respect the actions of the first, except that the direction of its course was different. It ascended again in the face of the wind, afterward moving steadily and continually in large curves accompanied with a rising motion and a lateral advance. Its motion was, in fact, so steady that I think a glass of water on its surface would have remained unspilled. When the steam gave out again it repeated for a second time the experience of the first trial when the steam had ceased, and settled gently and easily down. What height it reached at this trial I can not say, as I was not so favorably placed as in the first, but I had occasion to notice that this time its course took it over a wooded promontory, and I was relieved of some apprehension in seeing that it was already so high as to pass the tree tops by 20 or 30 feet. It reached the water one minute and thirty-one seconds from the time it started, at a measured distance of over 900 feet from the point at which it rose.

"This, however, was by no means the length of its flight. I estimated from the diameter of the curve described, from the number of turns of the propellers, as given by the automatic counter, after due allowance for slip, and from other measures, that the actual length of flight on each occasion was slightly over 3,000 feet. It is at least safe to say that each exceeded half an English mile.

"From the time and distance it will be noticed that the velocity was between 20 and 25 miles an hour, in a course which was constantly taking it "up hill." I may add that on a previous occasion I have seen a far higher velocity attained by the same aërodrome when its course was horizontal.

"I have no desire to enter into detail further than I have done, but I cannot but add that it seems to me that no one who was present on this interesting occasion could have failed to recognize that the practicability of mechanical flight had been demonstrated.

"Alexander Graham Bell."

No adequate pictures have been made of the actual flight of the aërodrome, which from the rapidity of its motion required very special preparation; but Dr. Bell made on the uniquely interesting occasion of the first flight some photographs with a small pocket camera, from which pictures have been taken. They are necessarily inadequate as pictures, but they distinctly exhibit the aërodrome as a distant and elevated object in the air.

II. PAPER FROM M'CLURE'S MAGAZINE.

[To partly satisfy a public curiosity which could not be altogether gratified, Mr. Langley wrote a wholly popular and untechnical account of the work which had gone on up to June, 1896, in McClure's Magazine. By the courtesy of the publishers he has been enabled to make considerable extracts from this article, which are reprinted here.

Attached to the present paper is an entirely mechanical reproduction of an instantaneous photograph taken by Dr. Alexander Graham Bell, showing the aërodrome in actual flight, and which has never before been published. The original was taken with a small pocket camera and has been very greatly enlarged for the present article. It is necessarily inadequate, considered as a picture, but it is uniquely interesting as giving a distinct exhbit of the aërodrome as a distant elevated object in the air. The woods beneath it are the trees on the secluded island of Chopawamsic, near Quantico, on the Virginia shore of the Potomac River about 30 miles below Washington, where the flight occurred on May 6, 1896.]

THE "FLYING MACHINE."*

. . . Nature has made her flying machine in the bird, which is nearly a thousand times as heavy as the air its bulk displaces, and only those who have tried to rival it know how inimitable her work is, for the "way of a bird in the air" remains as wonderful to us as it was to Solomon, and the sight of the bird has constantly held this wonder before men's eyes and in some men's minds, and kept the flame of hope from utter extinction, in spite of long disappointment. I well remember how, as a child, when lying in a New England pasture, I watched a hawk soaring far up in the blue, and sailing for a long time without any motion of its wings, as though it needed no work to sustain it, but was kept up there by some miracle. But, however sustained, I saw it sweep, in a few seconds of its leisurely flight, over a distance that to me was encumbered with every sort of obstacle, which did not exist for it. The wall over which I had climbed when I left the road, the ravine I had crossed, the patch of undergrowth through which I had pushed my way—all these were nothing to the bird; and while the road

A WING FROM A SOARING BIRD.

had only taken me in one direction, the bird's level highway led everywhere, and opened the way into every nook and corner of the landscape. How wonderfully easy, too, was its flight! There was not a flutter of its pinions as it swept over the field, in a motion which seemed as effortless as that of its shadow.

After many years and in mature life, I was brought to think of these things again, and to ask myself whether the problem of artificial flight was as hopeless and as absurd as it was then thought to be. Nature had solved it, and why not man? Perhaps it was because he had begun at the wrong end, and attempted to construct machines to fly before knowing the principles on which flight rested. I turned for these principles to my books and got no help. Sir Isaac Newton had indicated a rule for finding the resistance to advance through the air, which seemed, if correct, to

* From the Smithsonian Report for 1900.

† Here shown in reduced size.

* Reprinted, by permission, from McClure's Magazine, June, 1897. See also Story of Experiments in Mechanical Flight, by S. P. Langley, in Smithsonian Report, 1897, pp. 169 181.

call for enormous mechanical power, and a distinguished French mathematician had given a formula showing how rapidly the power must increase with the velocity of flight, and according to which a swallow, to attain a speed it is now known to reach, must be possessed of the strength of a man.

Remembering the effortless flight of the soaring bird, it seemed that the first thing to do was to discard rules which led to such results, and to commence new experiments, not to build a flying machine at once, but to find the principles upon which one should be built; to find, for instance, with certainty by direct trial how much horse power was needed to sustain a surface of given weight by means of its motion through the air.

Having decided to look for myself at these questions, and at first hand, the apparatus for this preliminary investigation was installed at Allegheny, Pa., about ten years ago. It consisted of a "whirling table" of unprecedented size, mounted in the open air, and driven round by a steam engine, so that the end of its revolving arm swept through a circumference of 200 feet, at all speeds up to 70 miles an hour. At the end of this arm was placed the apparatus to be tested, and, among other things, this included surfaces disposed like wings, which were hung from the end of the arm and dragged through the air till its resistance supported them as a kite is supported by the wind. One of the first things observed was that if it took a certain strain to sustain a properly disposed weight while it was stationary in the air, then not only to suspend it but to advance it rapidly at the same time took less strain than in the first case. A plate of brass weighing 1 pound, for instance, was hung from the end of the arm by a spring, which was drawn out till it registered that pound weight when the arm was still. When the arm was in motion, with the spring pulling the plate after it, it might naturally be supposed that, as it was drawn faster, the pull would be greater, but the contrary was observed, for under these circumstances the spring *contracted* till it registered less than an ounce. When the speed increased to that of a bird, the brass plate seemed to float on the air, and not only this, but taking into consideration both the strain and the velocity, it was found that absolutely less power was spent to make the plate move fast than slow, a result which seemed very extraordinary, since in all methods of land and water transport a high speed costs much more power than a slow one for the same distance.

These experiments were continued for three years, with the general conclusion that by simply moving any given weight of this form fast enough in a horizontal path it was possible to sustain it with less than one-twentieth of the power that Newton's rule called for. In particular it was proved that if we could insure horizontal flight without friction, about 200 pounds of such plates could be moved through the air at the speed of an express train and sustained upon it, with the expenditure of 1 horse power, sustained, that is, without any gas to lighten the weight, or by other means of flotation than the air over which it is made to run, as a swift skater runs safely over thin ice, or a skipping stone goes over water without sinking, till its speed is exhausted. This was saying that, so far as power alone was concerned, mechanical flight was theoretically possible with engines we could then build, since I was satisfied that boilers and engines could be constructed to weigh less than 20 pounds to the horse power, and that 1 horse power would, in theory at least, support nearly ten times that if the flight were *horizontal*. Almost everything, it will be noticed, depends on this; for if the flight is downward it will end at the ground, and if upward the machine will be climbing an invisible hill, with the same or a greater effort than every bicycler experiences with a real one. Speed, then, and this speed expended in a horizontal course, were the first two requisites. This was not saying that a flying machine could be started from the ground, guided into such flight in any direction, and brought back to earth in safety. There was, then, something more than power needed; that is, skill to use it, and the reader should notice the distinction. Hitherto it had always been supposed that it was wholly the lack of mechanical power to fly which made mechanical flight impossible. The first stage of the investigation had shown how much, or rather how little, power was needed in theory for the horizontal flight of a given weight, and the second stage, which was now to be entered upon, was to show first how to procure this power with as little weight as possible, and, having it, how by its means to acquire this horizontal flight in practice; that is, how to acquire the *art* of flight or how to build a ship that could actually navigate the air.

One thing which was made clear by these preliminary experiments, and made clear nearly for the first time, was that if a surface be made to advance rapidly, we secure an essential advantage in our ability to support it. Clearly we want the advance to get from place to place; but it proves also to be the only practicable way of supporting the thing at all, to thus take advantage of the inertia of the air, and this point is so all-important that we will renew an old illustration of it. The idea in a vague sense is as ancient as classical times. Pope says:

"Swift Camilla scours the plain,
Flies o'er the unbending corn, and skims along the main."

Now, is this really so in the sense that a Camilla, by running fast enough, could run over the tops of the corn? If she ran fast enough, yes; but the idea may be shown better by the analogous case of a skater who can glide safely over the thinnest ice if the speed is sufficient.

Think of a cake of ice of any small size, suppose a foot square. It possesses (like everything else in nature) inertia or resistance to displacement, and this will be less or more according to the mass moved. If the skater stands during a single second upon this small mass it will sink under him until he is perhaps waist deep in the water, while a cake of the same width but twice the length will yield only about half as readily to his weight. On this he will sink only to his knees, we may suppose, while if we think of another cake ten times as long as the first—that is, 1 foot wide and 10 feet long—we see that on this, during the same second, he will not sink above his feet. This is all plain enough; but now suppose the long cake to be divided into ten distinct portions, then it ought to be equally clear that the skater who glides over the whole in a second distributes his weight over just as much ice as though all ten were in one solid piece. So it is with the air. Even the viewless air possesses inertia; it cannot be pushed aside without some effort; and while the portion which is directly under the airship would not keep it from falling several yards in the first second, if the ship goes forward so that it runs or treads on thousands of such portions in that time, it will sink in proportionately less degree; sink perhaps only through a fraction of an inch.

Speed, then, is indispensable here. A balloon, like a ship, will float over one spot in safety, but our flying machine must be in motion to sustain itself, and in motion, in fact, before it can even begin to fly.

Perhaps we may fully understand what is meant by looking at a boy's kite. Everyone knows that it is held by a string against the wind, which sustains it, and that it falls in a calm. Most of us remember that even in a calm, if we run and draw it along it will still keep up, for what is required is motion relative to the air, however obtained.

It can be obtained without the cord if the same pull is given by an engine and propellers strong enough to draw it and light enough to be attached to and sustained by it. The stronger the pull and the quicker the motion, the heavier the kite may be made. It may be, instead of a sheet of paper, a sheet of metal even, like the plate of brass which has already been mentioned as seeming, when in rapid motion, to float upon the air, and, if it will make the principle involved more clear, the reader may think of our aërodrome as a great steel kite made to run fast enough over the air to sustain itself, whether in a calm or in a wind, by means of its propelling machinery, which takes the place of the string.

And now, having the theory of the flight before us, let us come to the practice. The first thing will be to provide an engine of unprecedented lightness that is to furnish the power. A few years ago an engine that developed a horse power weighed nearly as much as the actual horse did. We have got to begin by trying to make an engine which shall weigh, everything complete, boiler and all, not more than 20 pounds to the horse power, and preferably less than 10; but even if we have done this very hard thing we may be said to have only fought our way up to an enormous difficulty, for the next question will be how to use the power it gives so as to get a horizontal flight. We must then consider through what means the power is to be applied when we get it, and whether we shall, for instance, have wings or screws. At first it seems as though nature must know best, and that since her flying models, birds, are exclusively employing wings, this is the thing for us; but perhaps this is not the case. If we had imitated the horse or the ox, and made the machine which draws our trains walk on legs we should undoubtedly never have done as well as with the locomotive rolling on wheels; or if we had imitated the whale, with its fins, we should not have had so good a boat as we now have in the steamship with the paddle wheels or the screw, both of which are constructions that nature never employs. This is so important a point that we will look at the way nature got her models. Here is a human skeleton, and here one of a bird, drawn to the same scale. Apparently nature made one out of the other, or both out of some common type, and the closer we look the more curious the likeness appears.

Here is a wing from a soaring bird, here the same wing stripped of its feathers, and here the bones of a human arm, on the same scale. Now, on comparing them, we see still more clearly than in the skeleton that the bird's wing has developed out of something like our own arm. First comes the humerus, or principal bone of the upper arm, which is in the wing also. Next we see that the forearm of the bird repeats the radius and ulna, or two bones of our own forearm, while our wrist and finger bones are modified in the bird to carry the feathers, but are still there. To make the bird, then, nature appears to have taken what material she had in stock, so to speak, and developed it into something that would do. It was all that nature had to work on, and she has done wonderfully well with such unpromising material; but anyone can see that our arms would not be the best thing to make flying machines out of, and that there is no need of our starting there when we can start with something better and develop that. Flapping wings might be made on other principles, and perhaps will be found in future flying machines, but the most promising thing to try seemed to me to be the screw propeller.

Some twenty years ago, Penaud, a Frenchman, made a toy, consisting of a flat, immovable, sustaining wing surface, a flat tail, and a small propelling screw. He made the wing and tail out of paper or silk, and the propeller out of cork and feathers, and it was driven directly by strands of india-rubber twisted lamplighter fashion, and which turned the wheel as they untwisted.

The great difficulty of the task of creating a flying machine may be partly understood when it is stated that no machine in the whole history of invention, unless it were this toy of Penaud's, had ever, so far as I can learn, flown for even ten seconds; but something that will actually fly must be had to teach the art of "balancing."

When experiments are made with models moving on a whirling table or running on a railroad track, these are *forced* to move horizontally and at the same time are held so that they cannot turn over; but in free flight there will be nothing to secure this, unless the air ship is so adjusted in all its parts that it tends to move steadily and horizontally, and the acquisition of this adjustment or art of "balancing" in the air is an enormously difficult thing, and which, it will be seen later, took years to acquire.

My first experiments in it, then, were with models like these, but from them I got only a rude idea how to balance the future aërodrome, partly on account of the brevity of their flight, which only lasted a few seconds, partly on account of its irregularity. Although, then, much time and labor were spent by me on these, it was not possible to learn much about the balancing from them.

Thus it appeared that something which could give longer and steadier flights than india rubber must be used as a motor, even for the preliminary trials, and calculations and experiments were made upon the use of compressed air, carbonic acid gas, electricity in primary and storage batteries, and numerous other contrivances, but all in vain. The gas engine promised to be best ultimately, but nothing save steam gave any promise of immediate success in supporting a machine which would teach these conditions of flight by actual trial, for all were too heavy, weight being the great enemy. It was true also that the steam-driven model could not be properly constructed until the principal conditions of flight were learned, nor these be learned till the working model was experimented with, so that it seemed that the inventor was shut up in a sort of vicious circle.

However, it was necessary to begin in some way, or give up at the outset, and the construction began with a machine to be driven by a steam engine, through the means of propeller wheels, somewhat like the twin screws of a modern steamship, but placed amidships, not at the stern. There were to be rigid and motionless wings, slightly inclined, like the surface of a kite, and a construction was made on this plan which gave, if much disappointment, a good deal of useful experience. It was intended to make a machine that would weigh 20 or 25 pounds, constructed of steel tubes. The engines were made with the best advice to be got (I am not an engineer); but while the boiler was a good deal too heavy, it was still too small to get up steam for the engines, which weighed about 4 pounds, and could have developed a horse power if there were steam enough. This machine, which was to be moved by two propelling screws, was labored on for many months, with the result that the weight was constantly increased beyond the estimate until, before it was done, the whole weighed over 40 pounds, and yet could only get steam for about a half horse power, which, after deductions for loss in transmission, would give not more than half that again in actual thrust. It was clear that whatever pains it had cost, it must be abandoned.

This aërodrome could not then have flown; but having learned from it the formidable difficulty of making such a thing light enough, another was constructed, which was made in the other extreme, with two engines to be driven by compressed air, the whole weighing but 5 or 6 pounds. The power proved insufficient. Then came another, with engines to use carbonic acid gas, which failed from a similar cause. Then followed a small one to be run by steam, which gave some promise of success, but when tried indoors it was found to lift only about one-sixth of its own weight. In each of these the construction of the whole was remodeled to get the greatest strength and lightness combined, but though each was an improvement on its predecessor, it seemed to become more and more doubtful whether it could ever be made sufficiently light, and whether the desired end could be reached at all.

The chief obstacle proved to be not with the engines, which were made surprisingly light after sufficient experiment. The great difficulty was to make a boiler of almost no weight which would give steam enough, and this was a most wearying one. There must be also a certain amount of wing surface, and large wings weighed prohibitively; there must be a frame to hold all together, and the frame, if made strong enough, must yet weigh so little that it seemed impossible to make it. These were the difficulties that I still found myself in after two years of experiment, and it seemed at this stage again as if it must, after all, be given up as a hopeless task, for somehow the thing had to be built stronger and lighter yet.

(To be continued.)

FERRO-CONCRETE.

AT a meeting of the Society of Engineers held at the Royal United Service Institution, Whitehall, on Monday evening, a paper was read on "The Hennebique System of Ferro-Concrete Construction," by Mr. Augustus de Rohan Galbraith. The author stated that the originator of the principle was M. Joseph Monier, a Frenchman, and that it was first applied to the manufacture of slabs and pipes in ferro-cement. He then described the ferro-concrete system invented by M. Hennebique, a French engineer, which system has been widely introduced in practice in France, including the construction of a bridge of three arches at Chatellerault, 26 feet 3 inches wide, and having a center span of 172 feet and two side-spans of 135 feet each. This system is also being adopted in this country in various engineering works, notably in connection with the Old Quay widening, and new dock works of the London and Southwestern Railway Company at Southampton. The Hennebique principle consists in embedding in concrete straight and cranked iron or steel tension-bars and stirrups, to take the shearing-stresses, together with distance-pieces, the system being applicable to, and employed in, entire buildings from foundation to roof, inclusive. The piles used at Southampton are built up in vertical moulds, in which are placed long steel rods, which give the required strength. These are laced together with wire stirrups, and Portland cement concrete of the best quality is filled into the moulds and rammed round the steel. After a month the pile is taken out of its mould and driven in position, much in the same way as timber piles are. The ram is exceptionally heavy, generally 30 cwt. The head of the pile is protected from injury by covering it with a helmet, or iron case, filled with sawdust; a timber dolly is always used. The author then pointed out the care required in the selection and preparation of the materials, explaining that the usual proportions of the concrete were five to one, and giving the preference to Siemens-Martin steel over Bessemer steel, owing to the purer and more uniformly good quality of the former. He then dealt with the application of the system in general construction, giving the results of some tests of Hennebique beams with and without stirrups, which proved the superior strength of the former. He then stated that the results of experiments by Professors Bauschinger and Ritter showed that the adherence of iron to concrete was about 570 pounds per square inch. The co-efficient of expansion and contraction of

steel and concrete was found by M. Durand Claye to be identical up to the fifth decimal, giving the breaking strain of concrete as between 3,000 pounds and 4,000 pounds per square inch. The advantages of the system as regards fire resistance were then illustrated by the light of some severe fire tests carried out at Ghent, together with the results of a fire which occurred at a spinning mill at St. Etienne, Belgium, which proved that ferro-cement structures were perfectly fireproof. The author then gave the following examples of the cost of the Hennebique system as carried out in different structures: The Chatellerault Bridge, £18 12s. per lineal foot; a grain warehouse at Plymouth, 4½d. per cubic foot of space; a flour mill at Swansea, 4¼d. per cubic foot; grain-silos at Swansea, 6¼d. per cubic foot, and some coal hoppers at Portsmouth, 7¼d. per cubic foot.—Building News.

AN AUTOMATIC POSTAGE STAMP AND POSTAL CARD DISTRIBUTOR.

IN large houses in which the correspondence is extensive, the distribution of postage stamps always occupies considerable time, and the control of such distribution is in most cases difficult if not impossible. The object of MM. Thibaud & Co.'s distributor, illustrated herewith, is to assure the distribution of the stamps simply in exchange for special counters that have been given to the employés of different departments by the cashier of the house. These counters have the form of a sou and have the value of that coin. They are stamped with the name of the house upon one face, and, upon the other, with the name of the department by which they are furnished. When an employé needs a stamp, he operates the distributor, and when the business is closed at night, he gives the cashier an account of the counters that have been used and of those that remain on hand.

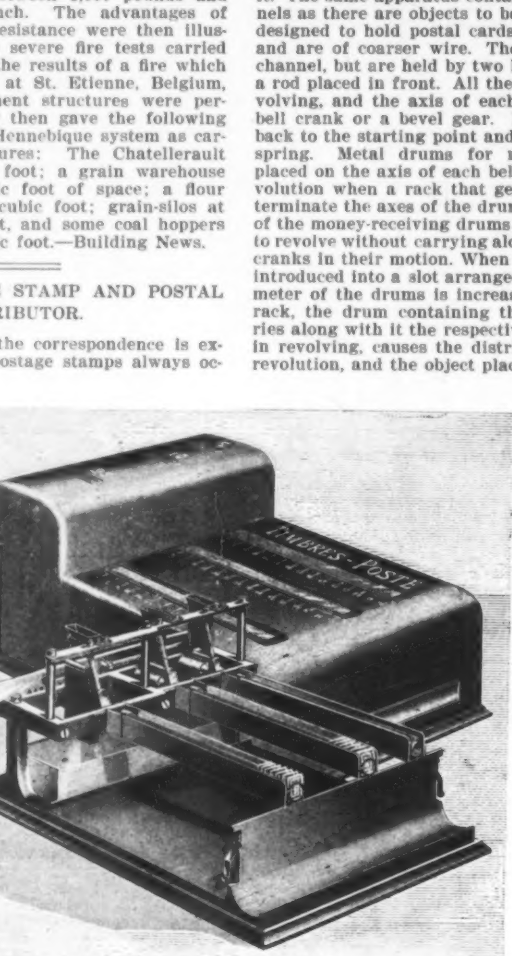


FIG. 1.—GENERAL VIEW OF AN AUTOMATIC POSTAGE STAMP DISTRIBUTOR (HORIZONTAL TYPE).

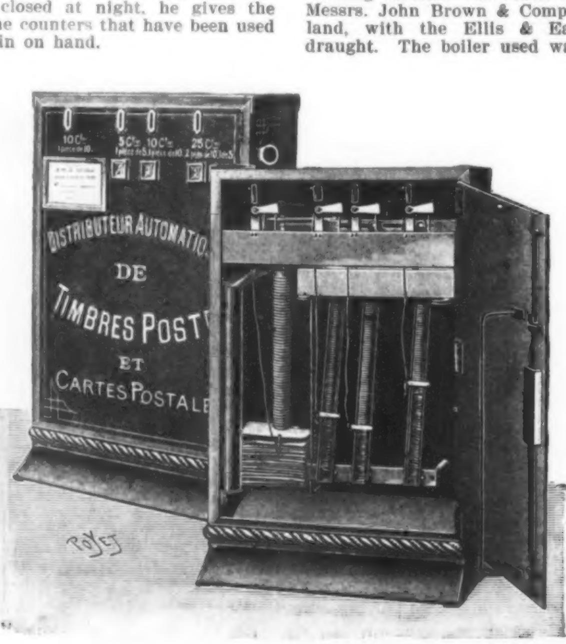


FIG. 2.—VERTICAL TYPE (INTERIOR VIEW).

In this apparatus, the manufacturers have made an application of the spiral spring to light and usually thin objects, such as postage stamps, postal cards, railway tickets, etc. The springs are made of nickel plated wire closely wound so as to leave but a slight space between each spiral, thus accommodating a large number of spirals in a short channel receptacle. The spring, at one of its extremities, has a core on whose axis is a small bevel gear in the vertical type of machine, or a small bell crank in the horizontal type. The other extremity of the spring is free. The diameter of the wire varies according to the weight and nature of the objects to be distributed. The objects are placed in the spirals, and each spring moves freely in the channel that guides it. The same apparatus contains as many of these channels as there are objects to be distributed. The springs designed to hold postal cards are of a larger diameter and are of coarser wire. The cards do not move in a channel, but are held by two lateral rods and guided by a rod placed in front. All the springs are capable of revolving, and the axis of each of them carries a small bell crank or a bevel gear. Each bell crank is pulled back to the starting point and held there by means of a spring. Metal drums for receiving the money are placed on the axis of each bell crank, and make one revolution when a rack that gears with the pinions that terminate the axes of the drums is pulled. The diameter of the money-receiving drums is such as to permit them to revolve without carrying along the corresponding bell cranks in their motion. When a coin of a certain size is introduced into a slot arranged for the purpose, the diameter of the drums is increased, and upon pulling the rack, the drum containing the coin revolves and carries along with it the respective bell crank. The latter, in revolving, causes the distributing spring to make a revolution, and the object placed in the last spiral falls into a receptacle. The entire mechanism is suitably encased, and nothing is perceived externally but the operating handle and the apertures for introducing the coins. Several of these distributors are now being tried in the Post Office at Paris.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

OIL BURNING WITH INDUCED DRAUGHT.

A TEST of the possibilities of a high-duty, oil-burning furnace was made recently at the works of Messrs. John Brown & Company, Ltd., Sheffield, England, with the Ellis & Eaves system of induced draught. The boiler used was of the ordinary multitubular marine type. The system consists in inducing a draught in the furnace by means of a fan which is placed at the bottom of the uptake or chimney. The air supplied to the furnace is passed through a tubular superheating arrangement by which its temperature is raised about 300 degrees Fahrenheit before delivering to the fires. This improves the combustion and reduces the temperature of the waste gases. The total heating surface of the boiler was 1,200 square feet. The usual coal grate was removed, and a solid brick pillar built in the center of each furnace tube. At the junction of the furnace tube with the combustion chamber, a perforated brick diaphragm wall was built to secure uniform dispersion of the intense heat. The back of the lower part of the combustion chamber was protected by brickwork from direct impingement of the flames. The results of a six hours' test were as follows: Water per pound of oil from and at 212 degrees Fahrenheit, sixteen and one-tenth pounds; water evaporated per square foot of heating surface from and at 212 degrees Fahrenheit, nine and nine-tenths pounds; efficiency of boiler, neglecting steam used for burners, eighty-four per cent. During the whole test no smoke was emitted from the chimney. Subsequently a short test of three hours' duration was made to ascertain the maximum evaporation which was possible with such a boiler when oil-fired, without producing smoke. The test showed that it was possible to force the evaporation up to 18,900 pounds of water from and at 212 degrees Fahrenheit per hour under these conditions. The evaporation was at the rate of fifteen and eight-tenths pounds of water per pound of oil from and at 212 degrees Fahrenheit.—Mechanical Engineer.

CONTEMPORARY ELECTRICAL SCIENCE.*

INERTIA OF A CURRENT IN A WIRE.—Maxwell made an experiment to determine whether any part of the kinetic energy of an electric current could be expressed by a term depending on the product of an ordinary velocity and an electric current. The velocity he considered was a velocity of the wire carrying the current in the direction of its length, and Lagrange's equations of motion show that if the term referred to exists, whenever a current is started or stopped in a wire, there would be an impulse acting on the wire in this direction. As Maxwell states, no evidence of any such effect has ever been discovered. W. S. Day has made a similar experiment, in which the mechanical coordinate considered is one such that its velocity means a rotation of the wire around its axis, the corresponding impulse when the current is suddenly started or stopped being an impulsive torque, if the term in question exists. No evidence of the existence of such an effect was discovered, but a maximum limit to its value was obtained. A wire was suspended by a quartz fiber. It was provided with two mercury caps to lead in the current, and the earth's magnetic field and certain electrodynamic and induction effects acting as sources of error were carefully eliminated. In Lagrange's equation of motion,

$$T = \tfrac{1}{2}\, I\dot{x}^2 + K\dot{x}\dot{y} + \tfrac{1}{2}\, L\dot{y}^2$$

where T is the kinetic energy, x the mechanical co-ordinate and y the electrical co-ordinate, the value of K per centimeter of wire cannot exceed 0.000016, according to the experimental result. For a current of 1 ampere decreasing to zero in 1 second, this would give a torque of 0.000016 dynes per centimeter of wire, and this was within the limits of experimental error. —W. S. Day, Phys. Review, September, 1902.

THE LAW OF INVERSE SQUARES.—S. J. Barnett points out a fallacy in the attempt to investigate the law of force in electrostatics by experiments on hollow closed conductors. The experiments of Faraday with hollow conductors, of one of which the experiment of Cavendish is only a particular case, have shown conclusively that the substance of a conductor cannot support a static field, and that a hollow closed conductor screens perfectly the region within it from all external electrostatic effect. There is no reason to suppose that this property of a conductor has anything whatever to do with the law of force. Indeed, it seems perfectly certain that the law of force depends only on the nature of the electrical displacement in a dielectric and the three-dimensional nature of space. If the displacement is continuous, or the electric flux along a tube of displacement constant, and the dielectric homogeneous and isotropic, the law of inverse squares is an immediate deduction. Thus, no matter what the law of force, there is no reason to expect to find an electric charge or an electric field within the substance of a conductor or on the inner surface of a hollow closed conductor in a static field. It therefore follows that the experiment of Cavendish is not conclusive, so far as the law of force is concerned. Electrostatics can be built up without Coulomb's law, as has already been shown by Pellat.—S. J. Barnett, Phys. Review, September, 1902.

MAGNETIC DOUBLE REFRACTION.—Q. Majorana has discovered in the case of magnetism an effect analogous to the Kerr effect in electrostatics. The particular effect described is a magnetic double refraction in solutions of ferric chloride and in colloidal iron oxide. The magnetic field employed was 7 cm. long, and had a strength of 18,000 units. The light was an arc or incandescent lamp. After placing the liquid in a small cubical vessel in the magnetic field, the light was transmitted through it and the nicols turned to obscurity. No light was restored by a magnetic field either along or across the plane of polarization. But a certain amount of light reappeared when the direction of the plane made an angle of 45 deg. with the direction of the field. In ferric chloride the ordinary and extraordinary ray showed a difference of path amounting to 0.02 or 0.03 of a wave-length. Dialyzed iron of density 1.002 gave a much more marked effect, amounting to one-third of a wave-length in the rod with a field of 18,000 units. Bravais iron in a solution of density 1.001 showed a maximum "Majorana effect" in a field of 3,000 units amounting to 0.6 λ. The colloidal iron shows the effect the better for being old, and it must not be coagulated. The effect is proportional to the square of the magnetic field.—Q. Majorana, Comptes Rendus, July 24, 1902.

MECHANICAL EFFECTS OF DISRUPTION DISCHARGE.—J. Semenov describes certain mechanical effects of the electric spark, which shed some light upon the transport of matter from one electrode to another. The experiments were conducted under ordinary atmospheric pressure, and the author comes to the conclusion that, contrary to the usual supposition, there is no transport of the material of either electrode, though the transport of the gas or vapor surrounding

* Compiled by E. E. Fournier d'Albe in the Electrician.

it is well marked, and gives rise to strong mechanical effects. The discharge from an induction coil was made to pass between a positive flame and a negative saline solution inclosed in a narrow tube about 1 mm. in internal diameter. The matter transported by the positive discharge impinged violently upon the solution, and made it spurt out in a luminous jet several millimeters long. The jet is spurted in the direction in which rays would be reflected. The spurting consumes energy, and consequently the cathode is much less heated than would otherwise be the case. The projected liquid is not chemically altered. That the spurting was not due to impact of the material of the anode itself was proved by making the anode consist of a jet of copper sulphate solution. This produced the same spurting, but without any $CuSO_4$ being transferred to the cathode, unless the jet was stopped and metallic vapor was formed by the heat then developed.—J. Semenov, Comptes Rendus, July 21, 1902.

ATOMIC WEIGHT OF RADIUM.—Mme. Curie has at length succeeded in obtaining pure chloride of radium, and has used the opportunity for determining the atomic weight of that remarkable metal. She is enabled to state definitely that it is 225 within a unit. It is, therefore, only surpassed in atomic weight by thorium (231) and uranium (238). It ranges itself among the metals of the alkaline earths, and is the superior homologue of barium, with which it is associated in nature. It also fits into the column in which thorium and uranium take their place according to Mendelejeff. The spectrum of the chloride was studied by Demarçay, who found the purest specimen practically free from barium. The amount of the substance available was 0.1 gramme, and the method consisted in estimating in the state of silver chloride the chlorine contained in a known weight of anhydrous radium chloride. To test the method, the atomic weight of barium was determined in the same manner, and found to lie between 137 and 138, the true figure being 137.4. The radium chloride is intensely radioactive and spontaneously luminous. Its effect upon the human skin and organism generally is most disastrous, as Mme. Curie has already experienced.—Mme. Curie, Comptes Rendus, July 21, 1902.

IONIZATION BY IONIC SHOCK.—J. Stark discusses the work of several recent investigations of the current in a gas and its dependence upon the E. M. F. His theory of ionization by ionic shock maintains that, in an ionized gas, the current at first increases with the E. M. F. until all the ions generated in the gas, whether by Röntgen rays, ultra-violet light, incandescence, or other artificial means, are used up by the current as fast as they are generated. When that is the case, an increase of E. M. F. produces no increase of current. But on still further increasing the E. M. F. a point is reached at which the ions, traversing their mean free path, acquire a sufficient velocity to ionize neutral molecules by their impact. The current then becomes "independent," and rises again with increased E. M. F. The E. M. F. current curve has, therefore, an ascending branch, a horizontal portion and another ascending branch. Such curves may be obtained from the data provided by Townsend, Stotelow, Lenard, Kreuster, Schweidler, McClelland and Kirkby. In some cases the curves are not complete as the point at which the independent current sets in depends upon the pressure, temperature and imported ionization of the gas. The positive ionizing potential is about 240 volts in air with an aluminium electrode, and 270 volts with a copper electrode.—J. Stark, Ann. der Physik, No. 3, 1902.

THE "PHENIX" ACCUMULATOR.

AMONG the accumulators employed in automobile work, one of the lightest and least bulky is the "Phenix." The electrodes of this accumulator are not plates, but cylinders, and consist (1) of a core of unattackable antimonious lead, the form of which is such as to present a wide surface of contact to the active material that surrounds it; (2) the active material of peroxide of lead or spongy lead; and (3) of special sheaths formed of superposed ebonite rings (for the negative electrode) and of tubes of porous earthenware (for the positive), which contain the active material pressed against the lead cores. This arrangement prevents the active material from getting out of place or falling and keeps it always intimately in contact with the supporting lead rods, so that it is consequently capable of withstanding shocks and jarring.

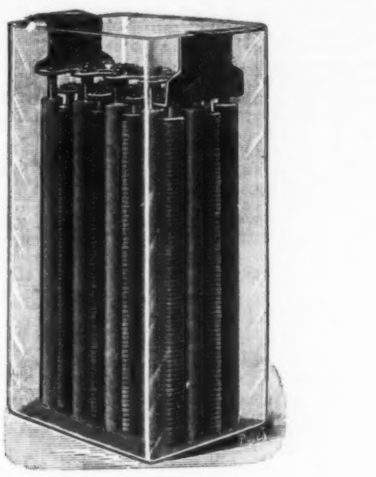
The porous cups employed are not acted upon by sulphuric acid, even when concentrated, nor are they attacked by the superoxygenated compounds that are produced during the operation of the accumulators. Furthermore, they offer no obstacle to the penetration of the acid solution and present little or no internal resistance, even at a one hour rate of discharge. Their chief feature is that they assure the complete insulation of the active material, and this prevents any possibility of short circuiting. Among the advantages afforded by this construction of the electrodes is, in the first place, extreme lightness, and, in the second, a great amount of active material in proportion to the weight of the supports; a large surface; wide distribution of the electrolytic action throughout the entire mass of the active material; and a perfect support of such material, which can no longer fall or become disintegrated, and the contact of which always remains excellent.

The result is an exceptional capacity, a perfect solidity, and an almost unlimited life.

In addition, the arrangement of the electrodes permits of the regeneration of their active material by inversions of polarity, when, through long use or an accident, the electrodes have lost their capacity. Through such inversions their primitive capacity is largely restored to them.

Tests of the "Phenix" accumulator have shown it capable of furnishing 15 ampere hours per kilogramme of electrode in a two hours' discharge; 18.75 ampere hours per kilogramme of electrode in a five hours' discharge; and 27 ampere hours per kilogramme of electrode in an eighteen hours' discharge. A five hours' charge at a constant potential of 2.5 volts, followed by a five hours' discharge at the normal rate, showed an efficiency of 95 per cent in capacity, and of 75 per cent in energy.

The accumulators are set up in the usual hard rubber jars employed in automobiles, and when thus set up they are easily transportable.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La France Automobile.



THE "PHENIX" ACCUMULATOR.

ELECTRICALLY-DRIVEN WELL-PUMP.

WE illustrate a convenient form of electrical pump which has recently been constructed by Messrs. Merryweather & Sons, of 63 Long Acre, London, W. C., for water supply at a large factory in the Midlands. It will be observed that the use of gearing is avoided, the pump being driven direct by a vertical shaft revolving in the well. The pump is of the "Hatfield" type described and illustrated by us in our issue of May 7, 1897; it is constructed with three barrels in one casting placed symmetrically around the vertical crankshaft, as shown in the plan, and the working parts are inclosed, the casing forming an oil bath to insure efficient lubrication. The pump is placed at a depth of about 70 feet from the surface, but as the water rises at times nearly to the ground level, it has been arranged that in case of necessity the pump may be raised without the employment of temporary pumps to lower the water level. The rising main from the pump incloses the revolving shaft, suitable bearings being placed at intervals, and the shaft is made in lengths, each having a square at the bottom fitting in a collar on the shaft below. When it is required to raise the pump, the pump-head and motor are removed, and then the whole apparatus may be raised, each length of pipe with its accompanying length of shafting being withdrawn as it reaches the surface. When it is required to replace the pump, the operation is reversed, and the position of the pump in the well is controlled by the provision of a cone, shown in the engraving, which acts as a guide to the suction pipe as this is being lowered. The motive power is provided by an electrical motor which is connected direct to the vertical revolving shaft, and the whole arrangement offers several advantages over ordinary treble-barrel well-pumps. The pump runs at 300 revolutions per minute, and is designed to raise 1,000 gallons of water per hour.—Engineering.

Fig. 1.

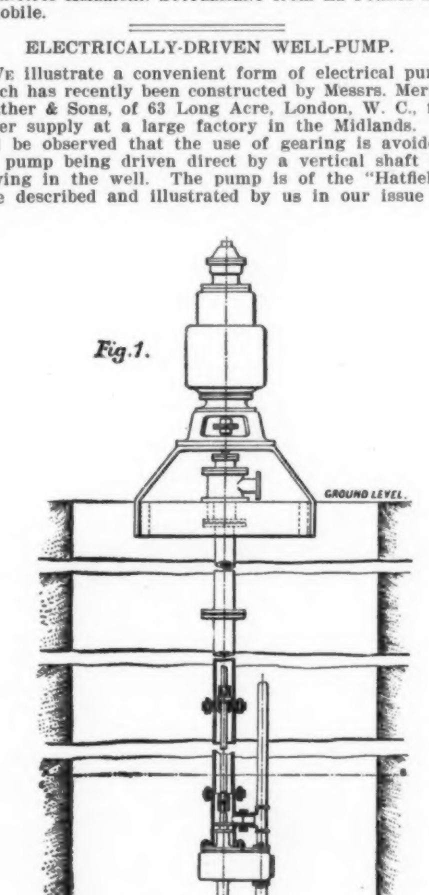


Fig. 2.
SECTION A.B

ELECTRICALLY-DRIVEN WELL-PUMP.

DISTRIBUTION OF LIGHT FROM THE NERNST LAMP.

THE engineers who developed the Nernst lamp kept in mind from the outset the importance of a correct distribution of light, and before determining the general form of the new lamp studied carefully the desirable and objectionable features of other illuminants. It was found that the horizontal rays from the arc lamp, for instance, were generally unsuitable, and after careful consideration, it was decided to make a more downward distribution of light from the Nernst lamp. In this connection it is interesting to note what is found in Nature. The sun at rising and setting projects its rays horizontally into our eyes, but at such times the light is much softened and the intensity greatly reduced. During the working hours of the day, however, the sun reaches a position in which the light can be greatly intensified without injury or discomfort to one's eyes. Our eyes are well protected from these vertical rays, but are unsuited for light projected in a horizontal direction, and it is obvious that we are unaccustomed to a horizontal distribution of intense light in Nature; at the same time it is uncomfortably evident that horizontal distribution is found in the methods of street lighting now in vogue. This refers more particularly to the arc lamp, which throws an abundance of light horizontally along the street, much after the manner of a search-light or locomotive headlight, with the result that horizontal rays of great intensity are projected into the eyes of pedestrians, teamsters and horses.

In the Nernst lamp it has been sought to avoid the error above described by more closely imitating Nature, and in a number of places where the Nernst lamp has already been introduced for street illumination the results have been found wonderfully pleasing. The lamps have been placed at about the same elevation as the ordinary arc lights and at varying intervals, according to the size of the unit selected. The result is that instead of the unsteady horizontal beams and the dense shadows underneath the arc lamp, we have a soft white light evenly distributed over the street, to the great relief of the eye.

In addition to this feature of throwing the light downward, the beautiful quality of the light emitted by the Nernst lamp has already made this form of illuminant very popular in dry goods stores and other places of a similar character where a correct determination of color is important. Moreover, it is interesting to note the pleasing effects which are now being produced with the Nernst lamp by using in large interiors only one quality of light, in distinction to the always unpleasant and inartistic combination of the bluish-white arc and the yellow incandescent. In this respect, the Nernst lamp offers for the first time a uniform quality of light in all sizes of units, and is the only electric light capable of being made in a practical and efficient form for both high and low candle powers.

The rapidly increasing use of the Nernst lamp is bringing out another feature with reference to artificial illumination, namely, a distinction between illumination and so-called artistic lighting. The latter is a field occupied almost exclusively by the incandescent lamp. Under artistic lighting may be classed illumination such as is now used on the outlines of large buildings, including, for instance, the beautiful effects produced at expositions, as on the electric tower at the Pan-American; also interior decorative work where color and the artistic location of the units of light are of primary importance. We may also include under this head electric signs. However, where general illumination is desired, it is obviously inefficient as well as objectionable from an optical point of view, as already shown, to place the units of light on the line of vision and then to throw the light upward, as is so often done with incandescent lamps.

An illuminant pure and simple should be placed well above the line of vision; in short, the location of the units of light should be such as to distribute the light in a manner more closely conforming to Nature. In other words, the lamps should be properly located in the ceiling and the light thrown downward. But here also an error is easily made. We frequently find a ceiling studded with small units of light, the idea being that an absolutely uniform distribution of light is the one thing to be taken as our object. This may be overdone. We do not find the heavens studded with small, brilliant lights; on the contrary our light comes from a single source placed at practically an infinite distance, and, although we cannot fully repeat these conditions, we can approximate to them more nearly than by studding the ceiling with unnecessarily small units. The objection to an absolutely uniform distribution of light in a room is that it destroys all shadow and gives one a weird impression, and not only is one's perspective thus distorted, but all the delicate lights and shades which otherwise make things appear beautiful are lost. On the other hand, we should not go to the other extreme of placing a single powerful light in the ceiling of a room, thereby casting unnaturally dense shadows. If we could place such an illuminant at a proper distance above the floor the result would approximate to Nature, but with the ordinary ceiling we must seek the happy medium, which will not be in the single large unit nor yet in the multiplicity of very small units, but in a sufficient number of properly

proportioned units of light so located as to cast pleasing lights and shadows.

Following along these lines, it may be shown further that drop lights and side lights are not only unnatural but actually injurious to the eyes; this includes also the desk light now commonly seen in all offices. The latter is usually provided with a green shade and casts a bright spot of light upon the letter paper, but if the eyes are raised the muscles of the eyes immediately relax to accommodate themselves to the darkness of the room and when they are again turned to the desk they contract. Such repeated involuntary action of the muscles of the eye must sooner or later produce harmful results.

The first requisite, therefore, of artificial lighting is a fair general illumination from above; then, if a reading or writing light is desired, it should be located well above the eyes and back of the reader so that the light will be cast over the left shoulder. As a writing light, the lamp may be placed well above the line of vision, preferably six feet from the floor and about a foot to the left of the writer's head, so that no shadow will be cast by the writing hand. The light should be thrown downward, giving a good general illumination over the entire desk or table.

To obtain the results above described has been the object of the makers of the Nernst lamp, and it is very gratifying to note that users of light are already learning to appreciate the benefits to be derived from a lamp which has been so carefully designed with reference to a proper distribution of light.

[Continued from SUPPLEMENT No. 1403, page 22480.]

THE UTILIZATION OF WASTES AND BY-PRODUCTS IN MANUFACTURES.*

WITH SPECIAL REFERENCE TO THE DECADE OF 1890-1900.

By HENRY G. KITTREDGE.

WOOLEN INDUSTRY.

THE woolen industry furnishes a number of materials formerly regarded as waste, that are now utilized in the industry itself and for pharmaceutical and other purposes. The principal articles of waste are rags and wool-grease. The former is reconverted into wool and used the same as the original raw material, while the latter is employed in other industries. The sheep obtains from the soil of the pastures upon which it feeds a considerable portion of potash, which, after circulating through the system of the animal, is excreted with other matter from the skin and becomes attached to the wool. This excretion is known by the French as "suint," and oftentimes constitutes, together with the dirt that is mixed with it, two-thirds of the weight of the fleece. Formerly the suint was allowed to go to waste when the wool was cleaned; and even now a large portion of it that is taken from the fleece is allowed to go to waste with the wash waters. There is a disposition at present, however, to recover the grease from the wash waters and use it for industrial purposes. At first, attention was directed to the saving of suint for the purpose of obtaining the potash and potash salts contained in it, and with this object a special industry was established in the wool districts of France and Belgium for converting it into commercial products, which were exhibited at the several industrial expositions in Europe, and especial mention was made of them at the Paris Exposition of 1867, many of them receiving silver medals.

The encrusting matters attached to wool, besides the dirt, consist of wool fat, which is soluble in ether, and wool perspiration, which is soluble in water. The wool fat and the wool perspiration are together embraced under the name of the "yolk" of the wool. The wool fat is a mixture of a solid alcoholic body, cholesterine, together with iso-cholesterine, and the compounds of these bodies with several of the fatty acids. These free higher alcohols are soluble in boiling ethyl-alcohol, while the compounds they form with the fatty acids are insoluble in alcohol but soluble in ether. Wool perspiration consists essentially of the potassium salts of oleic and stearic acids, and possibly other fixed fatty acids, also potassium salts of volatile acids, like acetic and valerianic, and small quantities of chlorides, phosphates, and sulphates.† Thus it will be seen that the yolk of wool contains many elements of recognized value in arts and manufacturing.

When the potash salts are evaporated and ignited, they yield a product of potassium carbonate, and it is estimated that 2,200,000 pounds of this product is saved from the wool wash waters of the mills and scouring establishments of France and Belgium. When the yolk is submitted to dry distillation it yields a residue containing carbonate of potash, nitrogenous carbon of great value for the manufacture of yellow prussiate of potash. According to M. Chandelon, 2,200 pounds of raw wool may furnish 300 quarts of yolk solution of 1.25 specific gravity, having a value of $3.75, while the cost of extraction does not exceed 60 cents.‡

It is only within comparatively recent years that volatile solvents have been used for extracting the yolk from wool. By far the greater quantity of wool is still cleansed by the old process of scouring with alkalies and washing in a rapid current of water. The volatile-solvent process, however, is coming into use, though now confined chiefly to establishments where large quantities of wool are cleansed. The great cost of the plant for cleansing wool by this method confines it to large establishments. Various volatile solvents can be used, such as fusel oil, ether, petroleum naphtha, and carbon disulphide. When these solvents are used they have to be followed by washing with water, as, while they dissolve fatty matters, they do not take up the oleates, etc., of the wool perspiration. The treatment of wool by these means is now confined to petroleum naphtha, and, as now conducted, according to the best methods in vogue, is found to be not only practicable but remunerative, both in the saving of a valuable product and in leaving the wool in an excellent condition for the various processes of manufacture.

In 1897 a bill was presented to the English Parliament, from the Bradford district, relating to the treatment and disposal of "suds" from the wool washbowls in combing sheds. At that time considerable interest was attached to a process which had been introduced at the works of Messrs. William Scaife & Co., wool combers, Laisterdyke. The process is described as exceedingly simple and apparently successful. The suds, after being run off from the washing bowl, are allowed to stand for about half an hour in a settling tank, to permit the sand and solid matter to fall to the bottom. The liquor is then pumped into a tank, very much like a washbowl, in the bottom of which is a system of pipes through which compressed air is forced. About one gallon of sulphuric acid is added to every 700 gallons of suds before the "blowing" begins. The violent aeration of the liquor which ensues quickly brings the grease to the surface in the form of a thick foam or froth, and a set of boards, carried on an endless chain, scrapes this off and carries it away over one end of the tank. The blowing is continued as long as any froth arises, which is just as long as there is any grease left in the water. The foam, which contains only about 5 per cent of water, is treated just as the magma, obtained in the usual way by precipitation, is dealt with —by pressure in a steam press.*

Within the past five or six years, several methods for cleansing wool, and for the recovery of the grease, etc., from the wash liquors, have been introduced into England and on the Continent, that have attracted considerable attention and comment from scientific journals. At the works of Thomas Biggart, of Dalry, Ayrshire, the recovery of grease and potash from the wash liquor is effected in the following manner: The suds from the first scouring bowl, containing about nine-tenths of the grease and potash, after standing about twelve hours to insure deposition of the sand, are evaporated in a pan until the liquid attains a sirupy consistency. The resultant liquid is then cooled in shallow iron trays, and the grease which collects on top is removed at intervals. The semiliquid residue is then calcined in a brick oven and the heat produced from it is used to assist in the evaporation. A crude carbonate of potash is thus produced, which, after being completely carbonated, is boiled to dissolve out the potash salts. The solution is then concentrated to 100 deg. Tw., the potassium sulphate and chloride crystallizing out on cooling. The potassium carbonate and grease obtained are sold.

In a recent type of machine—that of Emile Richard-Lagerie, of Roubaix, France—the wool is subjected successively to the action of liquors of diminishing strength, the last being clear water. The liquors, after having passed through the wool, are pumped into tanks for redistribution until they attain a density of 1.07, when they are evaporated and the residues calcined for the manufacture of potassium carbonate. Each machine is capable of dealing with about eight tons of wool per 24 hours.

The grease is extracted from the suds at the works of Alf. Matte & Co., Roubaix, by a mechanical process of "battage." The suds are, by means of a rotary agitator, beaten into a froth, which carries the fatty matters to the surface. These are skimmed off into conduits by a mechanical scraper, and are forced by a steam extractor into a wooden tank in which they are heated to 60 deg. C. and treated with sulphuric acid in the proportion of 1 pound to 100 gallons. The acid is then removed by washing and the grease is filter pressed.

In the establishment of Thomas Fox, Wellington, Somerset, the soapy liquors are led into six acidifying tanks and treated with sufficient acid to liberate the fatty acids. These on separating, together with the wool fat, are drained on sawdust filters. They are afterward taken off and purified by distillation for conversion into soap again. The dilute acid from the acidifying tanks is pumped into intermediate storage tanks for further settlement, after which it flows into the precipitation tanks and is treated with the general waste waters from the works, by aluminoferric, sulphate and lime.†

There has been a patent granted in England (No. 20,433, October 29, 1895) for improvements relating to removing, recovering, or separating certain constituents from the suint and obtaining certain valuable products therefrom. The solvent employed in this process for treating the wool is a heavy petroleum oil (specific gravity, 0.837 to 0.878) at a temperature of 120 deg. F. On cooling the resultant liquid to about 70 deg. F. the cholesterol of the suint separates out as a heavy deposit, while the glycerides remain in solution. This solution is found to be an efficient agent in scouring the wool, leaving it in a condition suitable for the subsequent carding, etc. The wool is treated with the petroleum oil in an ordinary wool-scouring bowl fitted with pressure rollers. One-half to one gallon of solvent is employed for each pound of wool. After about twenty minutes' action the greater part of the liquid is drawn off, and the operation is repeated if necessary. The wool is then treated with water or neutral soap, rinsed, pressed, and dried. After filtration the liquid is cooled, the deposit is removed, and the clear solution used again. This solution may also be employed as a lubricant or for use on leather, and since it contains no free fatty acids, it would seem to be better adapted for either purpose than the analogous mixture of degras and petroleum oil.

Among the most valuable improvements in treating wool fat and producing products therefrom are those covered by a United States patent (No. 539,386) recently granted to William D. Hartshorne, of Methuen, Mass., and Emile Maertens, of Providence, R. I. By the methods employed by these inventors five resultant products are obtained from wool fat. The object of the invention is to more thoroughly separate or divide wool fat into products possessing different properties and characteristics, so that the constituent parts of the wool fat, when obtained in a comparatively pure isolated state, are in the best form to be put to the various uses to which each is best adapted. This separation is considerably affected by temperature and by concentration of the solution from which and by which they are extracted. The fat products obtained are applicable to the following uses: (1) As a base for ointments and other pharmaceutical and toilet preparations on account of its penetrating, lubricating, and softening qualities. (2) As a leather and belt dressing, and, when freed from resinous matter, as a lubricant in conjunction with certain lubricating oils. (3) As a lubricant for wool and other animal fibers. This can be used to advantage to increase the specific gravity and viscosity of certain lubricating oils.

The inventors refer to wool fat as chemically a mixture or combination of cholesterin or its isomers or allied substances or alcohols with various fatty acids of resinous matters, and sometimes of such matters in a free state. The exact chemical relationship of these as they exist in the original wool fat on the sheep is, in the opinion of the inventors, very complex, and probably has never been accurately determined, and in the nature of the case may be indeterminable.

A number of patents have been granted of late years for cleansing wool by some solvent process. Among the important ones are those based upon the patents of Emile Maertens, of Providence, R. I., all of which relate to methods of treating wool and refining wool fat. The apparatus employed relates essentially to the economical removal and saving of the solvent adhering to the materials after their extraction, and particularly to the economical and safe treatment of wool with volatile solvents.

The process employed for degreasing wool is that of treating the wool in close digesters with the volatile solvents until a complete extraction is effected. One of the principal features of the process is the employment of compressed gas as a forcing or motive power to circulate the solvent through the wool under treatment. It is used to press the liquid solvent out of the wool as well as to blow out of it such solvent as has not been removed by pressure. It is also used as a heat-carrying medium to the wool and as a solvent vapor-carrying medium from the wool. It is furthermore used as an atmosphere wherein to carry on the extracting operation, both for covering the solvents in the reservoirs and for taking the place of the solvent removed from any part of the apparatus, and thus prevents the ignition of the solvent vapors by any electric or other spark which might accidentally be communicated to it; and since the gas is always moved in a closed circuit, it prevents the loss of solvent vapors, and can be used repeatedly without limit. It may be explained that the gas referred to by the inventor is an inert gas, or one which does not form explosive compounds with the vapors of the solvent used or with atmospheric air.

The great importance and growing appreciation of the solvent process of cleaning wool and preparing it for dyeing and spinning permits of special and more extended observations. Scientists and technical experts who have studied the wool fiber are unanimous in the opinion that it should be freed from its fat by means of volatile solvents, and not by the use of soapy and alkaline solutions, as has been heretofore the universal practice.

The earlier attempts to carry on the process of degreasing wool by means of volatile solvents were none of them successful from a commercial standpoint, although the rationality of the process was fully demonstrated in almost every instance by the superior condition of the wool thus treated. The problem was a very complex one to solve, requiring considerable mechanical engineering skill, knowledge of the wool fiber, of chemistry, due regard for the healthfulness and safety of the operation, and the blending of all these requisites into a system, the result of which would show a saving which could be expressed in dollars and cents.

In 1895 a plant for treating wool by the "solvent process" was put in operation by the Arlington Mills, of Lawrence, Mass., and was the first plant of its kind in the world that was commercially and technically successful. This plant has the capacity of degreasing 50,000 pounds of wool every ten hours, and has been run to its full limit ever since it was started. After an experience of six years with the solvent process, the Arlington Mills are now building a new plant to treat wool by this process which will have the capacity of degreasing from 200,000 to 250,000 pounds of wool every ten hours.

The saving effected by the "solvent process" to establishments that degrease and work their own wool for worsted purposes can be expressed in round numbers as averaging 2 cents per pound, figured on the greasy wool. This saving is made in the cost of the soap, which is entirely dispensed with by the new process; in a greater yield of the wool fiber since none of it is dissolved by soap and alkali; in a larger proportion of top to noil, because the wool being free from any felting, cards and combs freely without breaking of the fibers or the making of nibs; in a larger production of cards, combs, drawing, and spinning machinery; in the superior softness and appearance of the finished product; in the wool fat recovered, and in the potash recovered. The cost of the degreasing operation, including labor, solvent, power, interest, depreciation, etc., is, it is estimated, more than covered by the soap saved.

The average amount of fat taken out of such wools as are worked in the United States is 15 per cent, which at the minimum price of 3 cents per pound, represents 45 cents on every 100 pounds of wool degreased, and if to this is added also the value of the carbonate of potash recovered from the rinsing waters, which on an average amounts to 25 cents net per 100 pounds of greasy wool treated, we have 70 cents as the average minimum value of the by-products recovered from every 100 pounds of raw wool, or seven-tenths of a cent per pound of wool treated.

It is safe to say that from two to three million dollars' worth of wool fat and potash are run down the streams and wasted annually in the United States. If this wool fat instead of being wasted were recovered, refined, or separated into its constituent parts, its value would increase at least fivefold, and its uses would multiply. As the freighting expenses from some wool-producing districts to the mills or wool stores are often as high as 2 cents per pound, and average more than 1 cent per pound, for that part of the wool clip which is consumed in the Eastern and Middle States, and as the average shrinkage of the

* Census Bulletin 190.

† Industrial Organic Chemistry, 3d edition, Sadtler, page 306.

‡ Industrial Organic Chemistry, 3d edition, Sadtler.

* Public Health Journal, 1897.

† Journal Society of Chemical Industry, vol. 15, page 47.

wool clip is 60 per cent, and some wools shrink as high as 80 per cent, it will readily be seen that in some cases these freight charges will amount to 10 cents per pound on the clean wool, and that they average $2\frac{1}{2}$ cents per pound on clean wool. By establishing degreasing plants at the principal Western shipping points, millions of dollars worth of wool fat and potash could be recovered annually, and from 60 to 80 per cent of the freight charges, amounting to several millions of dollars more, could also be saved. Such a plan, if it were feasible, would have the further advantage of putting the wool upon the market absolutely clean, free from further shrinkage, and in the most perfect condition for working. In having wool cleaned at the shipping points, some system of grading or sorting the wool according to its qualities would necessarily have to be established in order to meet the requirements of manufacturing.

More progress has been made in the United States in the practical employment of the solvent process than in any other country. Plants have been recently erected in Belgium and Saxony, but not on so large a scale as exist in this country. The chief opposition to them is that of first cost, and the revulsion of manufacturers to the giving up of old methods. The cost of erecting a suitable plant is undoubtedly a serious obstacle in the employment of the solvent process, and to bring the process within the scope of the industry this obstacle may have to be removed.

The application of wool grease in the leather industry is familiar. Some experiments performed in Europe and described in the Journal of the Society of Chemical Industry in its issue of February 28, 1898, in "stuffing" a number of samples of leather with a mixture of wool grease and tallow, showed that the neutral wool grease penetrated the leather better than other fats of the same consistency; that it left no sticky touch or ill odor; and that, in the case of chrome-tanned leathers especially, it gave a very good color.

Wool grease under the name of "degras" is very largely used for stuffing leather. The term "degras," as employed in the trade in the United States, and as used in paragraph 279 in the customs tariff—where it is spoken of as brown wool grease—applies to grease extracted from the wool of sheep. In general use, however, the term "degras" is applied to oils and greases used by tanners without any special distinction, including what is known as "sod oil." Sod oil and wool grease have entirely different constituents as well as characteristics, and hence should be easily distinguished. Wool grease is extracted from the wool of sheep. Sod oil is expressed or extracted from leather which has been curried with oils, particularly fish oils. Sod oil has no relation to wool grease in its derivation, but is related to it in its use; that is, for the currying of leather. Sod oil contains a resinous substance (not a resin) known as degras former, which is characteristic of sod oil. No other oil or grease (and this includes wool grease which is, scientifically speaking, an animal wax and not a grease at all) contains this degras former, which is therefore characteristic of sod oil.* Originally sod oil was called degras. Later, the term "degras" was made by the American oil trade to embrace wool grease, and was adopted less extensively by the English. The term has therefore come to embrace two substances, dissimilar in constitution, source, and chemical constants.

The amount of degras that was imported and entered for consumption into the United States for 1899-1900 was 13,263,480 pounds, valued at $285,486.45, duties paid.

The most useful by-product of the woolen industry is undoubtedly woolen rags that may be reconverted into wool. Before these rags were used for this purpose, they were either thrown upon the waste heap to become manure or collected and used for the production of prussian blue and an inferior grade of paper. No waste of this kind is now permitted, but every woolen rag, in whatever form it may appear, unless completely worn out, is reused in manufacture, to appear again in clothing. Such rags are used and reused until there is absolutely nothing left of them that can be utilized, when they are mixed with hoofs, horns, and the blood from slaughterhouses, and melted with wood ashes and scrap iron for material out of which the beautiful prussian blue is made.†

Shoddy has been a part of the woolen manufacture since about the beginning of the nineteenth century, and its use is one of the necessary developments of the art of manufacturing, as, were it not for the supply from this source, there would not be a sufficient amount of raw material to meet the demands for clothing, except at very much increased prices over those that exist to-day.

Shoddy is not woolen rags ground to powder, but rags that are picked, leaving a good staple suitable for spinning. Some of the most substantial goods that are made, doing serviceable work for a number of years, contain a proportion of shoddy mixed with wool.

The largest amount of shoddy is utilized in the woolen industry of Great Britain; next to which comes that of the United States, where, in 1900, about 75,000,000 pounds were consumed, mostly in the manufacture of woolen fabrics, very little going into worsted fabrics, and that little placed upon the back of the goods, the worsted appearing upon the face. Practically all of the shoddy that is made in the United States comes from American rags. Only 314,597 pounds of wool waste was imported and entered for consumption into the United States for the year ending June 30, 1900. Very little of this consisted of rags, and still less of shoddy.

In recent years none but all-wool shoddy has been manufactured. During the civil war and prior thereto much of the shoddy for low-grade goods consisted of that made from rags with more or less cotton in them, especially in the warp. The improvement in the manipulation of rags, particularly those that contain more or less vegetable matter, as cotton, is due to the methods of destroying the vegetable material by means of acids and high temperature, both of which are necessary. These methods come under the general head of what is known in the trade as "carbonizing," which term applies strictly to the destruction of vegetable substances without essentially affecting the manufacturing qualities of the wool fiber. The shoddy thus produced goes under the general term of "extract," meaning simply that the wool fiber is extracted from its impure mixtures.

The acid commonly employed in carbonizing rags and making "extract" is sulphuric acid, in which the rags are allowed to soak for a short period of time and then subjected to a heat of from 200 degrees to 210 degrees in a close chamber, when the rags are removed and the acid neutralized by an alkaline bath, after which they are dried and shaken, the latter process converting all of the vegetable matter into dust. The rags, thus left with nothing but pure wool, are then sorted, picked in a machine known as the "shoddy picker," and otherwise treated in the same manner as original "all-wool" rags. The shoddy, or extract, that is thus made is absolutely clean and free from all deleterious matter, without the slightest possibility of conveying disease germs, and, in this particular, is freer than the wool obtained from many countries in the tropical and semi-tropical parts of the world. There is a process of carbonizing rags in which the dry system rather than the wet system (that of submerging the rags in a sulphuric acid bath) is employed. The acid used for dry carbonization is generally hydrochloric. There have been several patents taken out for the treatment of the rags by this process.

In 1896 an English patent was issued for an improved apparatus for carbonizing rags by the hydrochloric acid process, which, if allowed to act on the rags when perfectly dry, does not alter their color. Where the retention of color is essential the process is a valuable one, as by the wet process the colors are destroyed. By means of this improved apparatus the rags are placed in a perforated drum fitted radially with arms which do not reach quite to the center. A hollow shaft, which is heated in an adjacent chamber by means of furnace gas, enters at one end. Compressed hot air is allowed to enter the chamber containing the drum with the rags, either by way of the hollow shaft and through the rags or from the outside into the space surrounding the drum. In this manner the rags are perfectly dried. After the drying, hydrochloric acid is allowed to drop slowly from a funnel through the heated part of the hollow shaft into the drum, where it carbonizes the cotton in the rags.*

Preparation of acetone oil and ketones from wool washings is referred to in some of the European scientific journals.† A process is suggested for this purpose by making use of the volatile fatty acids contained in the liquid obtained by washing wool. The dry calcium salts of the volatile fatty acids thus obtained are distilled in the usual way, the yield being a mixture of ketones.

COTTON MANUFACTURING INDUSTRIES.

In the manufacture of cotton very little waste remains unutilized, but there have been great improvements of late in the methods for its more successful utilization for refabrication instead of being simply used for carpet linings, wadding, and batting. Nearly all cotton rags, and the same may be said of the linen rags, constitute valuable materials for the manufacture of paper. It is very difficult to destroy by mechanical means the physical identity of the cotton fiber. F. L. Simmonds in his "Waste Products and Undeveloped Substances," goes so far as to remark that—

"In this utilizing age it can not reasonably be expected that a waste product, such as rags, which have been proved to possess a length of staple, when broken up, sufficient for the spinning of common stuff, will be much longer permited to find its way exclusively to the paper mill. Like flock and shoddy, linen and cotton rags will be taken more from the paper maker, and raw vegetable fibers will have to be sought for or cultivated."

A large portion of the waste made in cotton mills, that is, such waste as has too short a staple for spinning, is used for such articles as batting and wadding. For this purpose 10,567,000 pounds were used during the census year of 1900, valued at $864,016.

COTTONSEED OIL INDUSTRY.

Closely allied to cotton manufacturing is the cottonseed oil industry, in which there has been a great revolution within late years in the utilization of the cottonseed, in obtaining most valuable commercial by-products, that were at one time allowed to go to waste with the seed in the form of manure. Cottonseed was a garbage in 1860, a fertilizer in 1870, a cattle food in 1880, and a table food and many things else in 1890.‡

The manufacture of cottonseed oil and all of its resultant by-products furnishes one of the best examples of the development of a business based upon the utilization of a waste product.

The seed of the cotton plant, of which cotton oil is the fatty ingredient, was for many years a waste product of the cotton field. The first cotton-oil mill was established in 1837, but for many years after the business did not amount to much; in fact, the real advances in this industry have been made in the past twenty years, with the greatest development in the last ten years. Prior to the advent of the oil mill and during the interval of its development cottonseed was used in some localities as a fertilizer. Later on it was used to a certain extent as a cattle food; but the main proposition seems to have been how to get rid of the seed with the least trouble, and, in fact, laws were passed in certain states making it a punishable offense for ginners within certain limits of towns to allow cottonseed to lie around and rot, or to dump it into streams.

It is computed that as late as 1870 only 4 per cent of the seed produced (from a cotton crop of 3,011,996 bales) was utilized in the oil business. In 1890 this had increased to 25 per cent of the seed on a crop of 7,472,511 bales, and in 1900 it was 53 per cent on a crop of 9,645,974.

According to the census of 1900, the value of the entire cottonseed crop was 13.8 per cent of the total value of the cotton crop, including the value of the seed, while the value of the products from the manufacture of all the seed produced would have been 20.4 per cent of the total value of the cotton crop.* Thus it will be seen that the full benefit of the cottonseed product to the planting and commercial interests of the South is not yet fully realized; not within $26,000,000 on the size of a crop equal to that in the census year of 1900. The seed which is not worked up in the oil mills is used for fertilizing, feeding, and planting. It has been unquestionably demonstrated that for feeding and fertilizing purposes the product of the cottonseed, after expressing the oil, has a greater economical value than does the whole seed, so that eventually the entire seed crop will be worked through the cotton-oil mills, with the exception of the amount reserved for planting.

The seed-cotton is brought from the fields to the ginneries, and there the fiber is removed, leaving adhering to the seed a short fiber, known as linters, the removal of which is the first process through which the seed passes in the oil mill, after the seed has been cleaned of trash, bolls, etc.

Cottonseed as it comes to the mill has a waste, due to sand, trash, etc., amounting to from 1 per cent to 3 per cent. The clean seed consists of about 2 per cent of linters, 48 per cent of hulls free from lint, and 50 per cent meats. These figures vary with different seasons and different localities, but they show the average of a number of localities and seasons.

The process of separating the different component parts of the seed is practically a continuous one. At the mills the seed is received into large houses and there distributed by means of conveyors and elevators to different parts of the shed or to the mill proper. All seed is thoroughly cleaned of bolls, trash, nails, etc., before going to the delinting machines. These consist of fine revolving saws closely set together, which tear off the short fiber left on the seed as it comes from the regular cotton gin. This product of the oil mill, known as linters, varies considerably as to quality and the quantity obtained, depending upon the seed worked. The average amount of linters taken from a ton of cleansed seed is from 20 to 30 pounds. It is of fairly good color and is used largely in the making of mattresses, felt hats, pillows, etc.

The seed, after passing through the delinting machines, is run through the hullers, which cut the seed so that when dropped upon the shakers and passed through the beaters the meats are thoroughly separated from the hulls. A ton of seed yields about 1,000 pounds of hulls. Perhaps one of the greatest developments in the business during the past few years is the utilization of these hulls for cattle food. Previously they were considered a great nuisance around the mills, and in order to get rid of them the mills used them for fuel, the ashes being utilized for fertilizers, as they contain a large amount of potash.

The separated meats pass from the shakers to rolls, where they are crushed, and from there they pass to cookers, where they are cooked to break up the oil cells. The cooked meats are then inclosed in camel's-hair mats and placed in hydraulic presses and subjected to a pressure of 2,000 to 4,000 pounds. The resultant crude oil is then pumped into settling tanks and certain impurities are allowed to settle out. The residue left in the press, after expressing the oil, is in the form of a hard cake. This is a most valuable by-product of cottonseed oil and amounts to about 725 pounds per ton of seed. The cake, either in the form of cake or after having been ground into meal (known as cottonseed meal), is used largely as a cattle food, or in the form of meal directly as a fertilizer, or as the principal ingredient in many prepared fertilizers. It is the best cattle food and fertilizer of any of the vegetable-oil cakes produced.

Mr. W. J. Booker, in "Flour and Feed," gives the following statement, based on a report of Prof. E. N. Jenkins, of the Connecticut State Experimental Station, showing the relative value of nitrogen, phosphoric acid, and potash contained in wheat bran, corn meal, linseed oil meal, and cottonseed meal:

	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	Pounds.	Pounds.
2,000 pounds wheat bran contains......	47.4	60.2	32.0
2,000 pounds corn meal contains......	29.0	12.8	8.0
2,000 pounds linseed oil meal contains .	106.0	38.8	20.2
2,000 pounds cottonseed meal contains	134.6	60.6	35.8

"Taking the nitrogen at 17 cents per pound, phosphoric acid at 6 cents per pound, and potash at $4\frac{1}{2}$ cents per pound (all of which are low valuations) gives the following as the manurial values:

	Per ton of 2,000 pounds.
Wheat bran............................	$13.03
Corn meal.............................	6.04
Linseed oil meal......................	21.55
Cottonseed meal.......................	28.04

"In feeding, the animal retains from 5 per cent to 20 per cent of the above elements, so that, taking 20 per cent from the above values, and taking wheat bran at $22 per ton, corn meal at $24 per ton, linseed oil meal at $28 per ton, and cottonseed meal at $27 per ton, after deducting the cost of the manure, it costs to feed—

	Per ton.
Wheat bran............................	$11.57
Corn meal.............................	19.16
Linseed oil meal......................	6.45
Cottonseed meal.......................	4.56"

It will be seen from the foregoing that cottonseed meal contains, by a large percentage, a greater amount of nitrogen (protein) than any other food. It is, in

* Erastus Hopkins, Journal of the American Chemical Society, June, 1900.

† Lord Playfair.

* English patent 25,708. 1896.

† Review of Chemical Industries, 1898.

‡ F. G. Mather, Popular Science Monthly, vol. 45, page 104.

* Census Bulletin No. 139.

fact, the most concentrated, cheapest, and most nutritious of foods, and in feeding, mixing it with bran, middlings, hulls, or other feeds, it produces an ideal cattle food. The tendency of the times is toward more scientific feeding, and the utilization of cottonseed meal, with its high percentage of flesh-forming properties, makes a great advancement over the old method of feeding the whole seed.

The foregoing products are all incidental to the production of crude cottonseed oil. The crude oil is allowed to stand in settling tanks for a number of hours, and is then ready for the refining process. There is obtained from a ton of seed approximately 275 pounds of crude oil. The oil varies in quality considerably, depending upon the condition of the seed and the locality from which it comes. It will vary in color from a light brown to a deep black. It contains varying proportions of red coloring matter and free fatty acids, depending upon the care with which the seed has been handled and the oil produced. The free fatty acids will vary from 0.4 per cent to as high as 30 per cent, but the average is in the neighborhood of 2 per cent.

The real advancement of the last twenty years in the cotton-oil industry has been made by the refinery. While there have been many improvements in the machinery of the crude oil mills, the process is to-day practically what it was many years ago, but when we turn to the refinery, the tremendous strides which have been made in the improvement of the refining methods result in a product so superior to the article produced years ago, that industries utilizing the oil, on account of this improvement, can use greater quantities of the oil than ever before.

Crude cottonseed oil, after its first process of refining, comes out in the shape of a clear, brilliant, yellow oil, known as summer yellow oil, having a specific gravity at 15 deg. Centigrade of 0.92. Owing to the deterioration of the seed and to inferior methods of manufacture, all crude oil does not produce yellow oil of the same grade. The trade has classified summer yellow oil as choice, prime, off, and soap oil, the difference in these grades being in the color and flavor. Choice oil is a light lemon-colored oil, without any suggestion of red, and is mild and neutral in flavor. Prime oil is slightly darker in color and sweet in flavor, without any seedy flavor. These two grades are used for edible purposes. The off and soap grades of oil are reddish in color and the flavor is very poor, due to bad seed, mustiness, etc. This oil is used for mechanical and soap purposes.

As intimated before, the amount of the different grades of oil produced depends largely upon the condition of the seed. It has varied from about 85 per cent to 35 per cent of choice and prime oil, and from 15 per cent to 65 per cent of off and soap oil.

With the improved refining methods of the past ten years has come increased demand and use for refined cottonseed oil. Summer yellow oil forms an important basis for a number of different products after being submitted to various processes, such as bleaching it to make it white and pressing it to extract the stearin.

One of the principal uses and development of cottonseed oil contingent upon the improvements in refining methods in the past decade is that of the manufacture of lard compound—a mixture of lard, oleo stearin, and refined cottonseed oil—making a most palatable and economical food. Another product of cottonseed oil, white cottolene, is a mixture of oleo stearin and specially processed cottonseed oil, marking, perhaps, the highest development of cotton oil as a food product.

Cotton oil is also used in the making of salad oils, packing sardines, in the oleomargarine industry, for miners' burning oil, cathedral burning oil, tempering oil, oil for heavy tool-cutting machines, mixing with putty, and, while not exactly a drying oil, yet for rough painting the crude oil can be and is used to a considerable extent. The cheapness of cotton oil compared with other fats, as well as its excellent soap-making properties, has caused it to be largely used by soap makers, both in America and abroad. It is also used in the manufacture of washing powders. Cottonseed oil is used to-day to a great extent by bakers. It is also used as a substitute for olive oil. Chemists and physicians now recognize cotton oil as a high-class food product.

In the refining process there is produced a loss amounting on an average to about 10 per cent of the crude oil. This forms an important by-product of the cotton-oil industry. This substance is known as soap stock, or foots. It has a fat acid content of from 40 per cent to 50 per cent, and is composed of free oil, coloring matter of the crude oil, and soap caused by saponification in the process of refining. It is used in making wool-scouring soaps and cheap grades of laundry soaps. It makes a most excellent soap. There is also produced from this substance glycerin, candle stock, olein, still pitch, etc. The number of uses of this last, though by no means least, by-product of the cotton-oil industry emphasizes the many uses to which this oil and its various products are put. It is of course impossible here to elaborate upon these, or even to fully enumerate them.

It should be borne in mind in dealing in or describing cottonseed products that in no two seasons are the conditions exactly alike, and the quality and quantity vary so much, that it makes it a constant study and a most interesting business.

(To be continued.)

NOTES ON SOME EXPERIMENTAL RESEARCHES ON INTERNAL FLOW IN CENTRIFUGAL PUMPS AND ALLIED MACHINES.*

By JAMES ALEX SMITH.

INTRODUCTION.

THE purpose of this paper is limited to bringing before the Institute simple means of rendering visible, or recording photographically the course of the fluid current in typical equivalents of hydraulic machines, especially in the rotary parts thereof. It is intended at a subsequent date (probably next month), with the permission of the Institute, to amplify this communication by exhibiting results of various combinations and giving some deductions arising therefrom.

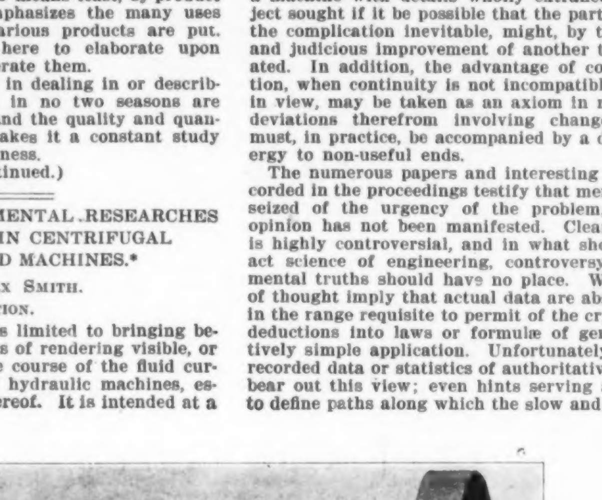


FIG. 1.

It is with diffidence that the writer ventures, in response to a call for a paper, to submit the appended notes. First, because they are, so far as he is concerned, in the nature of a by-product in another field of research, and therefore the adaptation of the instruments to hydraulic analogies, and the revision and elaboration of the rough jottings have not received that special attention and the time the subject properly merits; much must necessarily remain unwritten, much might have been more clearly expressed. Secondly, the problem has been dealt with so extensively—not exhaustively, for finality is not yet—that it would seem none but specialists of wide experience need hope for success. Still, the very importance of the question may justify the publication of any matter, however incomplete, provided it contains the germ of a new method of attack, or affords reasonable hope that in the hands of those competent to grasp the subject and its applications, it may give rise to consideration from a new point of view.

The broad question is of more than abstract or academic interest in general engineering; especially as regards irrigation, it is vital.

Throughout the whole of the variations of prime movers, those yielding the best results transmit energy through a revolving shaft or pulley. The most economical and compact reciprocating steam engines are found under this classification. Gas engines, with their great future, are, according to present design, essentially included. The electro motor and the steam or water turbine are almost the acme of the principle. Logically, a cheap, simple, compact, quick-running rotary pump directly connected and devoid of valves or mechanical complexities, is the complement of the motors referred to. Unquestionably the combination would be all but universal were the efficiency of the centrifugal on high or varying lifts and discharges comparable with that of its reciprocating rival.

It is nothing less than a mechanical barbarism to load a machine with details wholly extraneous to the subject sought if it be possible that the part which renders the complication inevitable, might, by the substitution and judicious improvement of another type, be eliminated. In addition, the advantage of continuity of action, when continuity is not incompatible with the end in view, may be taken as an axiom in mechanics. All deviations therefrom involving changes in velocity must, in practice, be accompanied by a diversion of energy to non-useful ends.

The numerous papers and interesting discussions recorded in the proceedings testify that members are fully seized of the urgency of the problem, but unity of opinion has not been manifested. Clearly the subject is highly controversial, and in what should be the exact science of engineering, controversy as to fundamental truths should have no place. Wide differences of thought imply that actual data are absent or lacking in the range requisite to permit of the crystallization of deductions into laws or formulæ of general and relatively simple application. Unfortunately the available recorded data or statistics of authoritative modern tests bear out this view; even hints serving as finger posts to define paths along which the slow and expensive processes of mechanical evolution might be most profitably pursued, are wanting, and the quality of the procurable machines negatives an inference that, for purposes of individual profit, the information is withheld, though extant. The matter is well worthy of systematic investigation, considering the number of services concerned, and the low efficiency of most, and even the best, centrifugals when judged by an ideal standard not apparently unattainable.

The mathematical treatment certainly has not been neglected; indeed, it is a question whether, in view of the existing stock of facts, it has not been pushed too far. Hypothesis based upon surmise ill supplies the place of theory established upon observed fact.

All seems to indicate the necessity of interrogating Nature—never silent to the earnest seeker after truth—by direct experimental methods, more especially as the ordinary designer, versed in users' requirements, workshop technique and limitations, is much more certain of his results when they arise from the consideration of matters within the category of the visible, or measurable, and not requiring mental translation from mathematical symbolism to the brain images of the concrete facts that symbolism is intended to denote.

The possibility of applying the "stream-line" method to rotors was casually alluded to when Prof. Hele-Shaw's beautiful experiments were yet novel—in fact the extension of the idea from the case of flow in planes at rest to streams in planes in motion was an obvious development—but it does not appear that the suggestion has materialized hitherto, either in actual apparatus or detailed specification.

It is not to be inferred that the instruments exhibited, and in which that principle to some degree enters, are in conception or in their incomplete state, capable of reaching to more than a partial solution of the many intricate possibilities and combinations. For instance, flow in the apparatus is (sensibly) in two dimensions only; in practice three dimensioned space must be dealt with. The entrance of fluid to the "eye" of the discs may not be in effect strictly analogous to the initial axial flow under actual conditions. In the

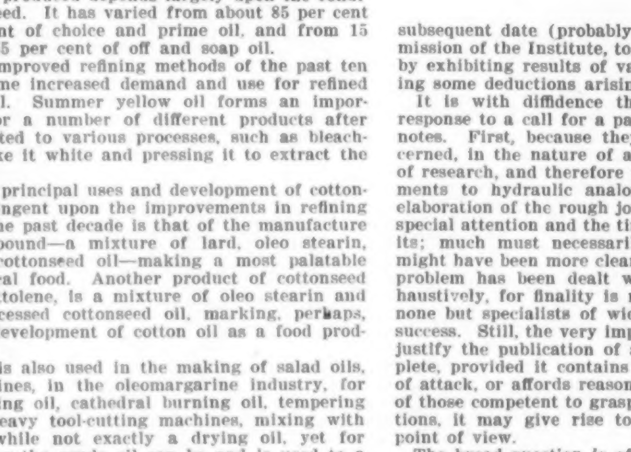


FIG. 2.

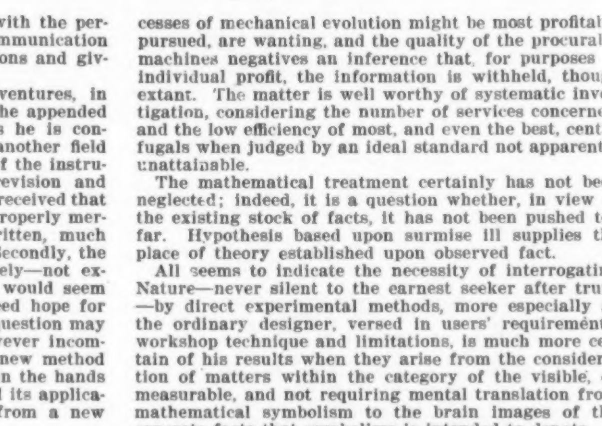


FIG. 3.

* Paper read at Victorian Institute of Engineers, and revised by the author for the SCIENTIFIC AMERICAN SUPPLEMENT.

experiment the discharge from the runners is into the atmosphere freely, in the pump into water under pressure.

Notwithstanding constructive restrictions, possibly removable, it would seem that useful work may be done in observing the *tendency* of the results arising from the forces in action. It may be that the engineer, with a graphic delineation before him, will, by the application of a series of variations, be enabled to some extent at least, to avoid the cumulative losses arising from impact, eddy friction, dead-water, constriction, undue length of path, and so on, all causes tending to dissipate the energy of motion in ultimate useless heat effects.

At least the means are of ready applicability. An idea may be tested or fixed, expeditiously, in miniature, in the laboratory, and at the cost of a little pasteboard and a trifle of time.

GENERAL DESCRIPTION.

Two instruments have been evolved, designated—tentatively—a Vorteximeter and a Volutimeter; the first is designed to analyze vortex or whirl in the runner, the second, the spiral current in a given casing.

In the vorteximeter fluid, or fluids, are supplied through a revolving shaft to a space separating two glass discs fixed pulley-wise upon the spindle. The discs are kept apart by pieces of card representing vanes. When the general stream outline alone is required a single colored fluid suffices; but when in addition the sliding over each other of integral laminæ is to be followed, two fluids must be used; the greater flow then consists of ordinary water, the lesser of filamentary streams of colored liquid injected into the main issue.

To measure the forms and motions of streams resulting from a high velocity of rotation, advantage is taken of the fact that the eye is capable of recognizing objects illuminated for an exceedingly short period—certainly less than 1-100,000th of one second—provided the light is of sufficient intrinsic intensity. Hence, if the rotating discs be lighted for a period so short that the angular motion during that time is negligible as compared with the magnitude of the movements to be observed, it follows that the disc will appear at rest. If, further, it is arranged that successive illuminations shall occur when the vanes are in the same relation to a fixed point, and at intervals of not more than one-tenth or one-seventh of a second, then the disturbance of the retina will continue between flashes, and the brain will receive the impression of a constantly illuminated object at rest, if the phenomena observed be constant. If there be a sequence of phases they will blend into a series giving the effect of change in a non-rotating body.

The speed of rotation of the discs is, of course, a quantity dependent upon the hydraulic problems to be treated, but whatever that speed may be with suitable adjustment, the discs seem stationary, although at low speeds the light may flicker.

In the volutimeter it has not, so far, been found expedient to rotate the runner. The instrument consists of glass planes separated by paper templets representing the casing to be tested, but the equivalent of the runner is fixed, and with orifices of efflux so designed that the effluent, supplied under pressure, shall at exit pursue a path as nearly as possible coincident with that of the discharge from an actual given runner. Flow is rendered apparent by mixed streams, but special illumination is not requisite.

The arrangement gives approximations, and is an application of stream line demonstration.

The scale of the instruments is arbitrary, but if the effects occur within a three-inch square, photographs—lantern-slide size—may be taken direct without a camera, and the derived positives enlarged by the optical lantern to any desired extent. In the case of the volutimeter direct projections may be made if the instrument itself be utilized as a slide.

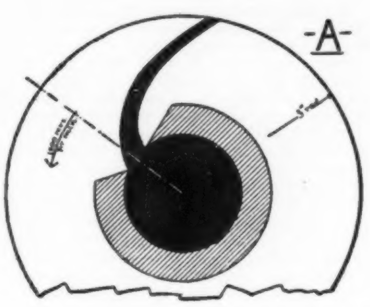
as a broad annular flow, the latter discharges through fine perforations. Motion is imparted to the axle by a bevel wheel (g) and trundle pinion (h), geared 6:1 or, alternatively, by a belt over a grooved pulley (i) on the shaft. For steady running either method may be used in connection with a motor or heavy flywheel, but when studying change of velocity effects, manual driving, with the intimate correlation of eye, brain and

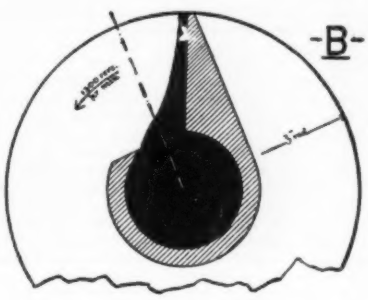
6,000 and that, or 1-6000 of unity represents the feeble illumination reaching the eye.

Illumination is a function of the factors named, not of the speed of revolution.

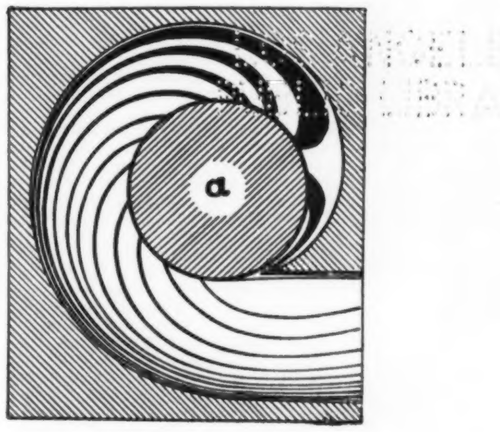
The electric arc or mixed gas jet would, under certain circumstances, be advantageous.

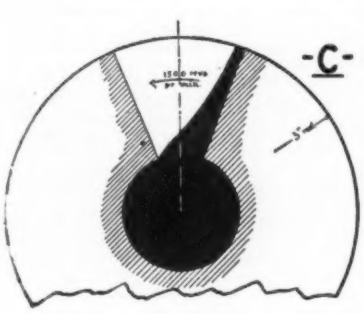
For visual work a sheet of finely ground glass placed immediately behind or before the glass discs, greatly





D





hand is preferable. Hand driving is effective up to 1,800 revolutions per minute.

Light is transmitted periodically by the rotating shutter (j), consisting of two plates of thin metal, fitting loosely on the shaft, until nipped in any position relative to each other or the glass discs, between the threaded pulley (i), and a milled nut (k). That plate nearest the light is furnished at a radius of two inches, with various holes and slots, the other has one horn-shaped aperture only, designed to cut out all those in the first plate save the one in use, and if required to reduce the length of that. Three slots, each half an inch long, and respectively 1-120th inch, 1-50th inch, and 1-10th inch wide, meet all requirements. The first used in a well-darkened room for fine markings, the second for general work, the third for photographic work or rough determinations. Light is derived from an acetylene flame (from a "ceetee" half-foot burner) inclosed in the lantern (m), collected and concentrated upon a slot in the cap (n) on the nozzle by a compound condenser consisting of two $1\frac{1}{2}$ inch diameter,

helps vision; without such aid only those parts of the discs immediately between the eye and the slot would be seen. Pot opal is too dense as a diffuser; flashed opal cannot be obtained in Melbourne. Much the best method is that finally adopted, viz., fine grinding of the back surface of the disc next the light. Clear glass is retained for photography.

Water, preferably boiled to expel air, is used as the colorless fluid, supplied per the tube (e) under a head of about 12 inches, and regulated by a pinchcock (o). The colored fluid under a head of about 20 inches flows by the tube (p). As coloring matter, permanganate of potash, logwood and iron salts, aniline "acid black," inks, etc., have been used, but as a good non-actinic, distinctive color aniline, "scarlet R.R." in a strength of about 30 grains per pint has been adopted. The splash guard (q) and waste pipe (r) collect and convey the discharge. Full view of the discs is afforded at all times.

If outlines alone are under consideration; one—a colored—fluid is used, but in that case escaping centrally,

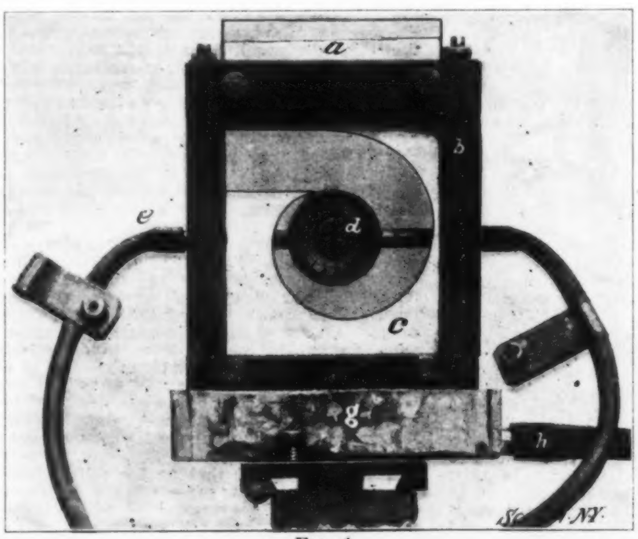


FIG. 4.

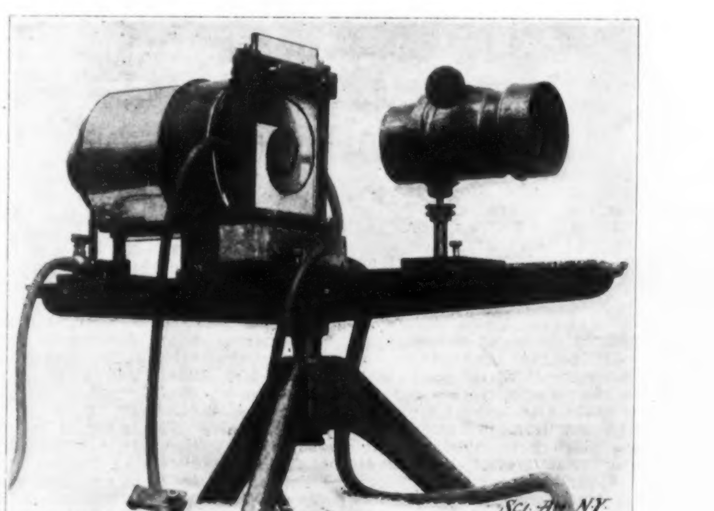


FIG. 5.

Optical enlargement will be found to much facilitate study.

DETAILS OF CONSTRUCTION AND USE.

Similar letters denote similar parts in related figures:

Vorteximeter, Figs. 1, 2 and 3. The disks (a) are of plate glass three-sixteenths of an inch by six inches in diameter, perforated centrally with three-quarter inch holes. They are carried and rotated by a shaft (b) running in bearings in a bracket (c); the front bearing (d) is coned and fits watertight in its bush, and by means of suitable ports and grooves provides two separate channels to the space between the disks for the clear (e) and colored (f) fluids. The former escapes

by 2 inch focus biconvex lenses, and a third similar focusing lens. The slot in the cap (just clearing the revolving plate) corresponds with that in the shutter. Interchangeable caps are preferred to a variable slit.

The optical problem is to pass as much of the available light through the slit as possible, and at such an angle that none of it shall be wasted by falling without the useful area of the glass disks. It must be remembered that only a fraction of the light finally reaches the eye. First it is cut down by the shutter in the ratio of the time of opening to time of eclipse, say 1:300, then the proportion of light from the flame reaching the slit is in the inverse ratio of the whole area of the flame mantle to the area of the slit, say (assuming the 1-50 inch slit) 1:20, hence the final ratio is 1:

not through the fine perforations, it may be caught and re-used indefinitely.

Speed of rotation at any particular phase is noted chronographically by electric contacts on the floor and driving mechanism (s).

Templets are cut from thin "three-sheet card," or enameling board, about 1-70 inch thick. Ribbon brass, lead foil, gutta percha, etc., have been tried; also variations of thickness through a considerable range, but 1-70 inch card is most satisfactory.

The general method of using the volutimeter, Fig. 4, is shown in Fig. 5, but it may be placed in any other suitable projection apparatus or used alone without lantern enlargement.

Two glass plates (a) with a paper templet (c) be-

tween them, are secured in a frame (b). The back plate is perforated with a one inch diameter hole, countersunk on the inner side. Within this opening is secured a brass plug and plate (d), permitting the entry of clear and colored streams through the tubes (e) and (f). The water is collected by the tray (g) and pipe (h).

It will not be found advisable to use paper more than 1-100 inch thick for the templets; these may be affixed permanently to loose strips of 26 ounce selected window glass (plate is theoretically better) by bichromated glue, and retained for reference.

RECORDING RESULTS.

Photographs are simply obtained. In the case of the vorteximeter, pieces of any smooth, thin, rapid bromide paper—Kodac glossy white "A" for instance—are cut to appropriate forms and sizes. Moistened with water they are squeegeed gelatine side to the glass by the fingers, the paper will adhere at all ordinary speeds. This simple method was arrived at after much more complex means had been tried. A slot of a third of an inch or more in width may be used. Crispness is here dependent, not upon speed of eclipse, but chiefly upon the parallax introduced by the thickness of the glass, a negligible quantity.

The preceding adjustments are made by ruby light, filtered through a strip of glass in the slot (t) in the lantern nozzle.

When adjusted, the machine is started, run until the correct phase is visible through the wet paper, and exposure made by raising the ruby glass slip. Exposure may be at discretion; with steady running a quarter of a minute may be given, for incipient cavitation, and with a special appliance to use concentrated sunlight a very small fraction of a second suffices.

The volutimeter effects may be dealt with as in ordinary photographic enlarging; this and development, etc., need not be dwelt upon.

The flow, located by lines etched (and darkened) in one of the discs, may be sketched, or it may be traced upon ground glass, gelatine or tracing paper. The results (the ground glass first varnished), or photo transparencies from negatives made as described and waxed, may be enlarged by lantern or camera.

VARIATIONS.

The discs need not necessarily be of glass nor planes. Glass may be worked to forms other than flat discs by the opticians' methods, or it may be turned in the lathe as though it were hard cast iron, by maintaining the tools keen and lubricating with turpentine. A sufficient finish may be given to the surface by grinding with pieces of copper or brass, then with wood, using emeries (with water) down to washed grades. Special channels of varying depth may be etched with hydrofluoric acid. Celluloid pressed, or non-absorbent marble worked to form may be utilized, in the latter case observing from the back by reflected light.

Photography by quick flash powders and the electric spark have been tried but are wanting in simplicity, and prevent attention being concentrated on main issues.

Eclipsers running 8,000 revolutions per minute have been used, but such high speeds were not found to be warranted by results.

Many other modifications were, in the course of the work elsewhere alluded to, tried, but they would more fittingly form the basis of notes on stream-line methods, and need not be further alluded to here.

Much small detail has been given above, because in the writer's experience the absence of minutiæ has frequently caused him wholly unnecessary labor in repeating other published experiments.

APPENDIX.

Figs. 1, 2, 3, 4 and 5 have been explained. The other illustrations are from effects to be shown to-night, although more fittingly they should be deferred to a future time.

A negative of a stencil between the glass discs when *at rest;* and one made when they were *running* at a speed of 35 revolutions per second prove conclusively that photographs may be implicitly relied upon to record the phenomena occurring between the discs when in motion.

A, B, and C are diagrams sketched from negatives taken at a speed of 1,500 revolutions per minute using one fluid.

A is the path (in the space between the glasses) of a fluid after discharge through a thin-edged aperture in an annular runner.

B is the same class of discharge restrained by a radial vane on the "trailing" side.

C is similar to B, but with a second radial vane added on the "leading" side.

Diagram D reproduces the result of a *radial* flow from the "runner" (a) into an Archimedean spiral casing.

DISCUSSION.

Mr. Smith, by the use of photographs and the instruments used, illustrated his paper.

The Chairman (Mr. Higgins) complimented Mr. Smith for his very interesting and instructive paper and experiments. He said we are on the eve of great advances in centrifugal pumps. When in Glasgow he saw pumps which were said to lift water 300 feet or so. The representatives of the firms did not feel free to give full particulars, but he understood that they were on the successive system, i. e., one pump feeding another. From their catalogue he ran out a few figures, and had found that instead of these pumps giving an efficiency of 70 per cent or 80 per cent they fell back to 30 or 40 per cent. He was not quite clear as to the truthfulness of the assertions made at the exhibition, that a pump lifted to the efficiency of 80 per cent. Another reason for his saying that we are on the eve of great advances in centrifugal pumps was that the well-known firm of C. A. Parsons & Co. had a skilled designer constantly employed in designing centrifugal pumps and their variations, and they were giving effect to the experiments performed. Dr. Hopkinson was giving almost his whole time, together with several assistants, to the question of centrifugal pumps. Another well-known firm, Messrs. Guinn & Co., were interesting themselves deeply in the subject. Coming nearer home was found the design of Mr. A. G. M. Michell, whose nomination paper was before the meeting, and he (Mr. Higgins) hoped that Mr. Michell would be at the next meeing. His design was for utilizing the kinetic energy of the water as it leaves the runner, and so far as he (the speaker) knew it was the most scientific yet out.

Mr. Higgins said that as most of the members present would no doubt like to read Mr. Smith's paper before discussing it, he thought it would be well to postpone discussion on the matter until next meeting.

Mr. Smith said that he proposed to supplement the results. Those just shown were merely to demonstrate the action of the machine.

Prof. Kernot said this question was one of the greatest problems of the present time. Statements occurred frequently in many books with reference to the efficiency of centrifugal pumps. There appears to be great difficulty in getting at simple facts. He had had no experience in the matter. What he wanted to know was, what was a fair expectation of the efficiency of a centrifugal pump of fairly good make in our present state of knowledge? Some books put it down at 60 per cent. Could we depend upon that? The chairman had mentioned that 30 or 40 per cent was about the usual thing. If that is all that could be obtained it was no wonder that the application of the centrifugal pump was so limited; but if 70 per cent could be attained, it had a very wide field. The whole question was a most tantalizing one. As to Mr. Smith's apparatus, he was immensely interested; it is a most ingenious and clever arrangement, and it is one that may be of very great value in clearing this subject. Mr. Smith had not taken anything for granted, but had proved everything.

Mr. Seitz said Mr. Smith deserved great credit for his apparatus, which would prove helpful not only to members of the Institute, but to persons all over the world. Respecting Prof. Kernot's query he said the efficiency could be taken at 65 per cent for centrifugal pumps of best makes.

Prof. Kernot: For what lifts?

Mr. Seitz: I consider that the height will not diminish the efficiency; 63 and 65 per cent could be obtained with a 12 inch pump on the brake horse power.

Prof. Kernot: Then if we can rely on the centrifugal pump giving 63 per cent efficiency the great majority of the plunger pumps should be thrown on the scrap heap.

Mr. Fyvie did not think that the results obtained from experiments could be altogether relied upon, owing to engine troubles, etc., and unless they could be absolutely relied upon they were worthless.

Mr. Seitz proposed, and Prof. Kernot seconded, that the paper be printed and the discussion postponed until next meeting.

THE CONTACT PROCESS FOR THE MANUFACTURE OF SULPHURIC ACID.*

I. Historical.—The production of sulphuric acid is a matter of the greatest importance, as it is not only the foundation of the inorganic heavy-chemical industry and is used for many other purposes, but also has lately become a most important material in the organic dye-stuff industry, especially in the production of alizarine colors and of synthetic indigo. The contact process is causing a complete revolution in the methods of manufacture of sulphuric acid; hence an account of its historical development and present status should be of great interest. The historical development of this process may be divided into four periods.

First period: Phillips, in 1831, discovered the catalytic action of platinum in hastening the union of SO_2 and O to form SO_3.

Second period: Wohler and Mahla, in 1852, showed that many other substances besides platinum possess catalytic properties, and explained the character and course of the reaction.

Third period: Winkler used definite gas mixtures for the production of sulphuric anhydride, as it was then considered that only in this way could good quantitative yields be obtained.

Fourth period, the present one, is noted by the successful use of the furnace gases directly.

The investigations of the third period were directed toward the production of fuming sulphuric acid, which was then very expensive, while the investigations of the first and second periods had the same end as the work of the present time; that is, the replacement of the chamber process by improved methods.

The catalytic action of platinum was discovered by Humphry Davy in January, 1818, who showed that platinum wire, when warmed and then introduced into a mixture of oxygen (or air) with H, CO, ethylene, or cyanogen, became incandescent, and that the gas mixture oxidized, usually gradually, but often rapidly.

Edmund Davy, in 1820, discovered that finely divided precipitated platinum, when moistened with alcohol and exposed to the air, becomes incandescent and the alcohol burns.

Doebereiner, in 1822, found that finely divided platinum, obtained by heating ammonio-platinic chloride, acted in the same manner, and, in 1824, that such platinum could ignite a stream of hydrogen, when this impinged upon it in contact with air, and utilized this discovery in his celebrated "lighting machine."

The honor of having first utilized this catalytic action, for the production of sulphur trioxide, is due to Peregrine Phillips of Bristol, England, who, in 1831, took out an English patent for his discovery, and, in 1832, Doebereiner and Magnus each confirmed the observations of Phillips. Although this discovery attracted much attention, nothing practical followed until 1848, when Schneider exhibited a working model of an apparatus, which produced sulphuric acid through the contact action of a specially prepared pumice. This alleged discovery was presented with great claims, but never was able to show a success, although wonderful results were confidently predicted. The same may be said of the method of Richard Laming, who also used a contact mass of pumice, prepared by boiling it in concentrated sulphuric acid, washing it in ammoniacal water, drying, and then impregnating it with about 1 per cent of manganese dioxide, finishing by heating the mass in a retort to 600 deg. and allowing it to cool out of contact with the air. Here we note for the first time, the use of another contact substance which, like platinum, can exist in various grades of oxidation, namely, manganese.

Especially noteworthy in this connection is the English patent of Jullion, 1846, because here, for the first time, the use of platinized asbestos as a contact mass is claimed. In 1849, Blondeau passed a current of a mixture of sulphur dioxide, steam, and air through a highly heated tube containing ferruginous, argillaceous sand and obtained sulphuric acid, while, in 1852, Wohler and Mahla found that oxides of iron, copper and chrome also work catalytically upon a mixture of SO_2 and O, a mixture of cupric and chromic oxides being especially efficacious. These investigators gave, moreover, a correct explanation of this catalytic action; they found, namely, that cupric and ferric oxide, when heated in a current of sulphur dioxide free from oxygen, became reduced to cuprous and ferroso-ferric oxides with simultaneous formation of sulphuric acid which, however, ceased as soon as the reduction of the oxides was completed. On the other hand, chromic oxide, under similar conditions, remained entirely unaltered and no sulphuric acid was produced, while metallic copper, in spongy form, exerts no action upon a mixture of 2 vol. SO_2 + 1 vol. O at ordinary temperatures, but, when heated, cupric oxide is first formed, and then sulphuric acid.

They also call attention to the fact that this union of SO_2 and O can take place in the complete absence of H_2O.

Upon these important discoveries are based the later researches of Lunge and others upon the catalytic action of pyrites cinder in causing the formation of SO_3. Quartz has also been recommended for this purpose, as have also platinized asbestos, platinized pumice, and even platinized clay.

Hundt, 1854, passed the hot roaster gas through a flue, filled with quartz fragments and heated by the gas, expecting to convert the greater part of the SO_2 into sulphuric acid with further treatment of the residue. The work of Schmersahl and Bouk, 1855, followed the same lines, as did also the method of Henry Deacon, which was patented in 1871, and may be considered as closing the second period.

So far, not only had all attempts to supersede the chamber process failed, but also no practical method for the production of fuming sulphuric acid had been devised. In 1875, Clemens Winkler published his celebrated researches upon the formation of sulphuric anhydride, for which industrial chemistry must always be greatly indebted to him, as originating successful methods for the economical production of the fuming sulphuric acid for which, as it has become cheaper, many new uses have been discovered.

Winkler concluded, as a result of his experiments, that the SO_2 and O should always be present in the molecular proportion of 2:1, any excess of either gas having a deleterious influence upon the completeness of the reaction, and he obtained this desired proportion by simply breaking up ordinary hydrated sulphuric acid into H_2O, SO_2, and O, removing the H_2O, and then recombining the SO_2 and O by means of appropriate contact substances, the preparation of which he greatly improved by utilizing the reducing action of formic acid. All subsequent work in this branch continued to follow the lines laid down by Winkler; hence, while little progress was made toward superseding the lead chamber, the manufacture of fuming sulphuric acid became highly developed.

II. Knietsch's Work—Purification of the Gas.—This work was undertaken by the Badische Anilin und Soda-Fabrik to determine if a complete conversion of the SO_2 in roaster gas was as practically feasible as it is theoretically possible.

It is well known that the outgoing gases of the chamber process still contain 6 volume per cent of oxygen, and that the roaster gas employed in the contact work contained a similar excess. Hence it was difficult to understand why, in the latter process, the yields were not nearer that of the former.

Experiments showed that when pure SO_2 was used the yield was close to the theoretical, even when a very large excess of O was present, which was contrary to the accepted views of Winkler.

When roaster gas was used in laboratory experiments it was found that when this was carefully cooled, washed with sulphuric acid, and completely purified before it was allowed to enter the catalytic tube, the results were very satisfactory, nor could any diminution of the efficiency of the contact mass be noted even after several days' use. It was therefore supposed that the problem had been solved, and arrangements were made to carry on the process on full working scale.

It was, however, soon found that in practice the contact mass gradually lost all of its efficiency, no matter how carefully the gases were cooled and purified. Extended laboratory investigations were undertaken to determine the cause of this inefficiency, and it was ultimately discovered that there are substances which, when present in the gas, even in excessively small quantities, injure the catalytic properties of platinum to an extraordinary degree. Of all of the substances which may be found in roaster gas, arsenic is by far the most deleterious, next mercury, while Sb, Bi, Pb, Fe, Zn, etc., are injurious only so far as they may coat the contact mass.

It was also found that as the white cloud of sulphuric acid which was present in the gas contained arsenic, the complete removal of this was necessary, although such removal had always been considered an impossibility. This was, however, finally accomplished after an enormous expenditure of time, labor, and money, so that, in the end, by extended washing and filtration, the gases were obtained in a condition absolutely free from all impurities. (D. R. P. 113,933, July 22, 1898.)

Slow cooling of the gas was found to be absolutely necessary as a preliminary to its purification. It is a fact, the cause of which is not yet clearly known, that the removal of the white cloud is rendered far more difficult if the gas is rapidly cooled.

To insure slow cooling, a system of iron tubes was used because it was supposed that, as the sulphuric acid in the gas was in a so highly concentrated condition, any action upon the metal would yield SO_2 only. It was now found that although the contact mass re-

* R. Knietsch, Ber. d. d. Gesell., 1901, page 4069.

mained active for a much longer period, it still gradually lost its power, no matter how carefully the gas was purified. The cause of this was ultimately found to be a gas containing arsenic, probably hydrogen arsenide, produced by the action of the acid upon the iron by which hydrogen was evolved, although the formation of this gas under such conditions had always been considered impossible. As soon as the cooling apparatus was so arranged that no condensed acid could attack the iron, the trouble from this source entirely ceased.

A final difficulty occurred in the occasional formation of a faint cloud of unburnt sulphur which contained arsenic. The cure for this was found to be a proper mixing of the hot gases, thus insuring complete combustion, and this mixing was effected by means of steam, which is also beneficial, by diluting the strong sulphuric acid present in the gas, so that it did not condense in the iron pipes of the first portion of the cooling apparatus, and attack them; when condensing in the lead pipes of the remainder of the apparatus, the acid was too weak to injure the lead. The use of steam also prevented the formation of hard dust crusts, which tend to stop up the pipes.

III. Cooling of the Gases.—The next important element in the successful carrying out of the contact process is the effective and economical utilization of the heat developed by the reaction which is exothermic.

$$SO_2 + O = SO_3 + 22600 \text{ cal.}$$

The utilization of this heat had been suggested by Lunge, but only in the case of the use of a mixture of pure SO_2 and air, containing about 25 per cent of the former. On the other hand, it was universally considered that it was necessary to employ extra heat when the much weaker roaster gases are to be treated. Hence the apparatus used in this work was furnished with special heating arrangements so that the tubes could be kept at red heat, the tubes being arranged vertically like those of an upright boiler. Small, vertical tubes are much superior to the larger, horizontal ones, originally employed, as economizing the expensive platinized asbestos and insuring a more certain contact of the gases with the mass. The proper filling of the tubes with the asbestos is a matter of importance; it must be so done that no portion of the gas can pass through a tube without coming in contact with the mass, while the mass must not offer much resistance to the passage of the gas. Owing to the nature of the asbestos, this latter difficulty is likely to occur, but can be avoided by the simple device of packing the asbestos in successive layers, separated by perforated diaphragms sliding upon a central rod, but kept apart at regular intervals. In this way all of the tubes can be similarly and evenly packed.

As soon as this apparatus was started in the ordinary way at low red heat, the surprising discovery was made that not only was the output of acid increased, but that the strength of the gas current could be made greater when the tubes, instead of being heated artificially, were, on the contrary, cooled by the admission of cold air. This discovery, a contradiction of what had been considered correct practice, gave a rational method of work; i. e., the apparatus must be systematically cooled to obtain the maximum effect and production. As now operated, the tubes are cooled by the cold, purified gases, which thus become heated to the proper temperature for the reaction. In this way the following advantages are gained:

First. Overheating of the apparatus is avoided, and thus a yield of 96 per cent—98 per cent of the theoretical—is obtained.

Second. The iron parts of the apparatus are protected by this cooler working, and are therefore more durable.

Third. The contact mass does not become overheated and its efficiency remains unimpaired.

Fourth. The absolute efficiency of the contact mass, and of the entire apparatus, is greatly increased because the rapidity of the gas stream can be increased, and the contact mass be maintained at the most efficient temperature.

Another important discovery is that the reaction proceeds at atmospheric pressure, since it was formerly supposed that compression of the gases was necessary to overcome the hindrance of the indifferent gases present. In fact, if the other conditions are right the reaction proceeds almost quantitatively at atmospheric pressure. This is very important since, if this method is to compete with the chamber process, every unnecessary expense must be avoided.

IV. Absorption of the Produced Anhydride.—The affinity of sulphuric anhydride for water is greater than for concentrated sulphuric acid, as shown by the relative amount of heat developed during the absorption; hence it might be expected that the easiest and most complete absorption of anhydride from the contact process would be effected by the use of water. It is found, however, that oil of vitriol containing 97-99 per cent of H_2SO_4 is much more effective than either water or sulphuric acid of any other strength. The absorbing power of the acid at this degree of concentration is so great that a single absorption vessel is sufficient for the removal of the SO_3 from a very rapid current of gas, provided that the strength of the acid be kept uniformly between the above limits by a steady inflow of water or weak acid, and a proportional outflow of the excess of strong acid thus produced.

Sulphuric acid, at this particular degree of concentration, possesses certain marked qualities. Its boiling point is a maximum, so that if a weaker acid is evaporated, it loses water or weak acid until the residue attains a strength of 98.33 per cent H_2SO_4, at which point it distills without further change at a constant temperature of about 330 deg. Similarly, a stronger acid gives off anhydride until this constant strength is reached. Again, at this particular degree, the vapor pressure is at its minimum, the specific gravity is at the maximum, the electrical resistance suddenly rises, while the action on iron decreases considerably.

When fuming sulphuric acid is to be made, one or more absorption cells must precede the regular apparatus. For these, cast iron, which is quite suitable as the material for the other vessels, becomes unavailable, because, although it is only slowly attacked, it, what is worse, becomes fragile and even explodes. This appears to be due to the fuming acid diffusing into the iron and then breaking up into SO_2 and H_2S, thus causing a condition of internal stress. Wrought iron is attacked by fuming acid containing less than 27 per cent of SO_3, but when the contents of anhydride exceed this, the acid has practically no action upon wrought iron, and vessels of this material can be used for years without sensible corrosion.

V. Theory of the Contact Process.—The results of many experiments showing the influence upon the reaction of variations in the temperature, the composition of the gases, the rate of flow (or the proportion of contact substance over which the gas passes) are given in the form of curves, and discussed, yielding the following results:

1. Complete conversion of the SO_2 into SO_3 occurs only when there is at least twice as much oxygen present as the reaction formula indicates. When using the gas obtained from the roasting of pyrites, and which contains about 7 vol. per cent of SO_2, 10 vol. per cent of O, and 83 vol. per cent of nitrogen, the nitrogen is absolutely without influence upon the reaction, except as diluting the gas and reducing the output.

2. The completeness of the reaction depends solely upon the temperature and not upon the nature of the contact substance. The reaction begins at about 200 deg. As the temperature rises, so does the degree of conversion, until, at about 400 deg., a nearly complete (98 to 99 per cent) conversion of the SO_2 is feasible. Any further rise in temperature is injurious, the degree of conversion falling so that at about 700 deg. only about 60 per cent can be converted, while at about 900 deg. the reaction ceases entirely.

3. The nature of the contact substance has no influence upon the completeness of the reaction, but, for practical results, a substance must be employed which shows a high degree of efficiency at the proper temperature of 400 deg. Substances which require a higher temperature to develop their greatest efficiency, are evidently unsuited, since, as shown above, the degree of conversion falls with the rise in temperature. Up to the present time only one substance fulfilling the necessary conditions is known, and that is platinum. None of the other metals of the platinum group approaches it in efficiency.

This valuable paper concludes with a series of tables, giving the results of exhaustive sets of determinations of the following properties of sulphuric acid, and of fuming sulphuric acid of various strengths from 1 to 100 per cent of SO_3.

1. Melting point. 2. Specific gravity. 3. Specific heat. 4. Heat of solution. 5. Electrical resistance. 6. Action upon iron. 7. Boiling point. 8. Vapor pressure. 9. Viscosity. 10. Capillarity. 11. Table giving the percentage of free SO_3 in a fuming sulphuric acid when the total contents of SO_3 is known.

Production of Sulphur Trioxide.—The growth and present magnitude of the operations of this process in the works of the Badische Anilin und Soda-Fabrik are shown in the following figures:

	Tons.
1888	18,500
1894	39,000
1899	89,000
1900	116,000

It will be seen from the foregoing, that this process has long passed the experimental stage, and now that the general conditions of successful operation are known, its speedy adoption in this country is to be expected. The advantages are many: First, no expense of construction and maintenance of the entire chamber system, including the Gay-Lussac and Glover towers and the steam and niter plant. Second, no expense for niter and for the sulphuric acid used therewith; although the resulting niter cake can be utilized, it is rarely a desirable product. Third, the acid produced is pure, strong oil of vitriol, requring no concentration for sale or use. Concentration of chamber acid to high strengths requires the use of platinum stills, which thereby lose in weight, the dissolved platinum being irrevocably lost. The rate of loss is much reduced by previous purification of the acid, but is always a considerable item of cost. Fourth, the contact acid is also free from arsenic, lead, or iron salts. The fundamental difference in the character of the reactions in the chamber process and of those in the contact method indicates the possibility of substantial improvements in the methods of roasting. Fifth, although the 50 degree acid, as it comes from the chambers, is desirable for many purposes—for example, in making superphosphates—it is held by some authorities that it can be made more cheaply by diluting the strong acid with the needed proportion of cold water, than by introducing this water into the chambers in the form of steam. This, however, is denied by others, and it is probable that the chamber process will continue to exist, though in a more restricted field.

On the other hand, this new process appears to require a well planned and carefully managed system of purification for the roaster gases, and will need, for its successful operation, a higher order of chemical engineering skill than has usually been deemed necessary for the operation of an acid plant. This, however, should hardly be considered an obstacle in this country, where all other branches of engineering manufacture have reached such a height, mainly because the works have demanded and made liberal use of the highest order of trained ability, and have not hesitated to "scrap" expensive plant where it failed to give satisfactory results. In this connection the Badische Anilin und Soda-Fabrik is an instructive example. Its chemical force numbers over 100 men, many of whom are engaged solely upon researches, the results of which, when promising, are at once put into operation on a sufficiently large scale to determine their practical value. That such a course pays in a strict business sense is shown by the enormous dividends paid by this company, and by the practical monopoly which it has long maintained in certain lines, simply because it has been a little ahead of its competitors in knowing just how a given thing should be done, and then at once protecting the discovery by patents.—From Twelfth Census.

THE FIGURE OF THE EARTH.

THE fascinating discourse before the British Association on the Figure of the Earth by Major S. G. Burrard, R.E., Superintendent of Trigonometrical Surveys, concerns the very basis of many of our astronomical and geodetic measurements. We are uncertain regarding the figure of our earth and the reliability of our plumb-line. Major Burrard remarked in his introduction that the distance between Waterford and Londonderry (nearly 200 miles, fairly on the same meridian) might be measured within 2 ft. of 3 ft.; the difference in latitude between the two places might be determined within 5 ft.; yet a deflection of the plumb-line might introduce an error of 800 ft. Major Burrard, however, spoke mainly on India, where his own splendid work has been done. Thanks to the foresight of the East Indian Company, continuous survey measurements have been carried on for over a century, so that we have eight meridional and four longitudinal arcs available for general discussion. The principal station for reference of latitude is Kalianpur, whose latitude had been settled at 24 deg. 7 min. 11.10 sec. The question is, however, How is the astronomical zenith situated with regard to the geodetic zenith? There is the enormous mass of the Himalaya Mountains to the north of Kalianpur, and it had been assumed that the mountains attracted the plumb-line toward themselves. General Walker, however, came to the conclusion in 1895 that the plumb-line at Kalianpur was not really deflected to the north, but to the south, and that therefore Kalianpur was assumed to be 2 seconds of arc more to the north than it really is. Pratt had believed in an error of 4 seconds, and there was an uncertainty of 7 seconds. In order to settle this question, Major Burrard and Captain L. Conyngham selected four stations, about 9 miles from Kalianpur, and four more about 35 miles distant for latitude determinations. The results differ from Walker's, and show that north of Kalianpur—that is, nearer to the Himalayas—the deflection of the plumb-line is to the south, and south of Kalianpur, to the north. But if the mass of mountains is capable of producing a deflection of 38 seconds at Dehra Dun (near Delhi), then its effect should be felt all over India. The Himalaya mass alone clearly could not explain the difficulty. But there might be a deficiency in the density of the earth beneath the Himalaya range, while there was evidence to assume the existence of high density strata beneath the Vindhya range. The pendulum experiments could not decide whether there was a deficiency of mass under the point of observation, or whether the point was situated on a higher level—that is, further away from the earth center—than we had assumed. In this sense, and having regard to the uncertainty of what we call sea level, the position of some station in the Himalayas was uncertain by 8000 ft. Near high plateaus and mountains, as in India, the sea might permanently be lifted up. Although the heights of all our mountains are so insignificant that we can hardly draw sections of large areas on a correct vertical scale, this uncertainty is important. Major Burrard moreover inclines to agree with Clarke, who regards the equator as an ellipse, not as a circle. On such a spheroidal earth, with the one diameter ending in Rhodesia and the Pacific longer by 2½ miles than the other, discrepancies could not but result between astronomical and geodetical determinations. Just for this reason, however, Major Burrard differed from those who considered India, with its situation south of Tibet and the Himalayas, and between two oceans of largely unknown depths, as unsuitable for the laborious and difficult work in which the Indian survey is engaged.

Captain Lennox Conyngham having added remarks in agreement with these views, Professor Shuster expressed his admiration for the perseverance shown; scientific prestige should be appreciated as much as military prestige. Mr. Plummer, of Bidstone, and Professor Turner also spoke.

EARTHQUAKES. THE SEISMOLOGICAL COMMITTEE.

Mr. J. Milne, F.R.S., of Shide, Isle of Wight, illustrated at the British Association meeting at Belfast two interesting papers by lantern slides, "Observations on Earthquakes," and the "Report of the Seismological Committee." He is the secretary and soul of this Committee. We will take the two communications together. The report is the seventh of its kind, but the Committee has been in existence for 41 years. The seismographs recommended by the Committee are now in use at 37 stations, and the instruments on board the Discovery, now on her Antarctic Expedition, bring the number up to 38. England has three stations, at Shide, Kew, and Bidstone (near Birkenhead); Scotland two, at Edinburgh and Paisley; Germany one, at Strassburg; France and Italy none; Russia three; Spain and Portugal one each; the Azores two. The other stations are in Africa (Cairo and Cape Town); Australia (Melbourne, Sydney, Perth); Canada (Toronto, Victoria, B.C.); India and Ceylon (five); Mauritius (one); New Zealand (two); Honolulu; Java (one); Japan (one); Mexico; South America (Argentina, Arequipa); United States (Philadelphia, Baltimore). It will thus be seen that the number of similar instruments is not large, but other instruments are used elsewhere. The report describes the various pendulums in use at Shide. When in Japan, in 1891, Mr. Milne devised a clinometer to record the tilting of the ground that earthquakes several hundred miles away might produce. The instrument was essentially a balance beam, loaded at its extremities, which was assured to retain its horizontality when its frame was tilted in a direction at right angles to its length. Recently Mr. Milne has set up a similar large clinograph at Shide, consisting of a beam 5 ft. in length, with a pointer 4 ft. in length. But no records of distant earthquakes have been obtained with it, nor has W. Schlütter, at Göttingen, been more successful with a clinograph of his own. Vertical spring seismographs, to measure the vertical component of large waves, have not proved successful either. According to Dr. Omori, the amplitudes of seismograms are not dependent upon the sensibility of the seismograph to tilting, and the movements represented by large waves are horizontal rather than undulatory.

The interpretation of the records obtained with horizontal pendulums and other instruments remains, therefore, very difficult. Yet, Mr. Milne said, we can keep in touch with the outside if we watch our instruments. The photographic records, drawn by the horizontal pendulum, begin with a preliminary tremor, in which sometimes two vibrations—a short one, followed

by one of greater amplitude—can be distinguished; the big waves set in after that. The tremor is most likely caused by compressional waves, which pass through the earth, along chords, at the rate of 7 or 8 kilometers per second. The large waves are probably surface waves, which move less fast. Professor C. G. Knott now accepts the surface-wave hypothesis. The intermediate second vibration phenomenon may be due to distortional waves. The duration of the preliminary tremor is an indication of the distance of the origin. Ten minutes is the limit by which the second phase of motion is outraced by the tremors, and this limit is reached at a distance of 90 deg. or 100 deg. from the origin.

The origins of earthquakes have been classed in groups. The chief groups are marked by letters of the alphabet, and the numbers which we place after the names indicate the number of earthquakes credited to the districts in 1900 and 1901. Mr. Milne's groups are: Alaska (25); Cordillerean Region (14); California, Mexico, and Central America (14); Antillean Region (16); Andean, South America (12); Japan (29); Java and Sunda Isles (41); Mauritius (17); North-Eastern Atlantic (22); North-Western Atlantic (3); North Atlantic (3)—all the earthquakes from these three Atlantic origins are small and not well defined; Alpine, Balkan, Caucasian, and Himalayan Districts (14). This last group is the only Continental region, and it might be subdivided into four or more groups. The map of the earth used for illustrating these regions also showed the chief mountain and submarine ridges, and Mr. Milne pointed out that where we have very steep slopes, as in Alaska, where Mount Elias rises to 18,000 ft., while the near sea has a depth of 2,200 fathoms 60 miles from the shore, there we find earthquakes. At Alaska the slope is 100 ft. per mile; in Mexico up to 500 ft.; South America, 500 ft., etc.; in Japan and Java, as in the Antilles, where the slope comes up to 1,000 ft. over a distance of 12 miles, the great depth of the sea, 4,600 fathoms near Japan, is decisive. If elevation goes on in such ridges, and the bounding furrows are deepened, we may expect that the displacements will be accompanied by earthquakes and volcanic eruptions. Mr. Milne demonstrated such a connection for the Antilles, pointing to the late eruptions on Martinique and St. Vincent after the Guatemala earthquake of April 19, and he quoted other examples of depressions and elevations of enormous areas from the Mississippi Valley, Peru, Caracas, Japan, &c. He also exhibited Helmert's and Albrecht's diagrams connecting earthquakes and the rate of movement of the earth's axis. With regard to the fight between fire and sea at Krakatoa, he remarked that it had not been accompanied by any magnetic disturbances. The earthquake registers from Kew (on alluvium), Shide (chalk), Edinburgh (Palæozoic felstone), Bidstone (red sandstone), show peculiar differences, for which the nature of the soil can hardly account. Kew records fewer earthquakes and of shorter duration than the others; Shide and Bidstone mark most earthquakes; the amplitudes are least at Kew and Edinburgh. Experiments are being continued with pendulums of different natural periods and differently mounted.

In the discussion, Professor H. H. Turner expressed the hope that we might learn to predict earthquakes; the wobbling of our polar axis might produce earthquakes, but not *vice versa*. Professor Schuster wished to have the question definitely settled whether instruments exactly like magnetometers, but not of iron, would not be affected like the magnetometers, and complimented Mr. Milne upon his excellent work; Mr. Milne had initiated the International Association, and the British Association was foremost in this domain.—Engineering.

NEW APPARATUS FOR STERILIZING WATER.

One of the most important factors in the transmission of epidemic diseases is certainly drinking-water. Upon this point all hygienists are agreed. Everywhere where epidemics of typhoid fever, dysentery and cholera have occurred, it has been demonstrated that the germs of such diseases had been transmitted by water of bad quality. So all the efforts of municipalities have for some years past been directed toward assuring cities a supply of good potable water. But this sometimes necessitates considerable work as well as an expense that is out of proportion to the resources of the community to be supplied. Moreover, when the intense heat of summer comes on, the consumption is considerably increased, and, as the spring water impounded at a great expense becomes inadequate, it is necessary to have recourse to river water. During the summer of every year, the population of Paris is supplied, partially at least, with water from the Seine or Marne, or in other words, with water that is not protected against contamination.

Hygienists have therefore been led to seek a method of freeing water from pathogenetic germs—from the dangerous microbes that it may contain. For this purpose, the simplest method is to boil the water designed for drinking. Such a measure of precaution, in order to be efficacious, must be effected under certain conditions, either under pressure or for a sufficiently prolonged period, say 15 or 20 minutes at the least. On the other hand, boiled water has the drawback of having lost the greater part of its natural gas, and this renders it difficult of digestion and deficient in extractive materials. Moreover, it possesses a disagreeable taste, and, besides, before it is drunk it must be cooled. As the cooling is in most cases done in the air, the result is that the liquid is liable to become contaminated through germs floating in the atmosphere. These make it of inferior quality from a sanitary point of view. Finally, boiling is a troublesome process that requires the use of a large quantity of fuel, and this renders it absolutely inapplicable when a great quantity of water has to be furnished.

Although heat is the most certain agent for the destruction of pathogenetic germs, there are other means that have permitted of obtaining pretty good results, and during the last few years a large number of apparatus designed for the sterilization of water have been proposed. Some of these are based upon mechanical processes and others upon chemical or physical ones. Although these different processes have some advantages, they all present serious drawbacks. So efforts are being made every day to devise apparatus that shall be more perfect and capable of effecting a complete sterilization of water and, at the same time, of preserving the properties that characterize a potable liquid, that is to say, an agreeable taste, a low temperature, and a sufficient proportion of gas to assure easy digestion.

Numerous types have already been mentioned in this journal. The one that we are about to describe is the result of the collaborative work of Prof. Vaillard and M. Desmaroux. This apparatus may be applied as well to the sterilization of large quantities of water for public use as to the production of sterilized water for a single house or a single family. In both cases, the principle applied is the same. So we shall confine ourselves to a description of a 250 gallon sterilizer of the type installed at the Polytechnic School and the Military School of Saint-Cyr.

MM. Vaillard and Desmaroux, employing heat as the agent of sterilization, have endeavored to obtain: (1) A complete sterilization of water at a temperature of at least 100 deg. C.; (2) a preservation of the organoleptic character of the liquid; (3) a production of water immediately fit for consumption; (4) a minimum output of fuel; (5) a relatively cheap apparatus that is portable, of simple installation, and that requires little or no attention.

The principle of the sterilizer that they have devised consists in the progressive reheating of the water to be sterilized, and, at the same time, of the cooling of the liquid, which has been raised to the temperature of sterilization, that is to say, to 110 deg. or 115 deg. C. The apparatus consists essentially of the following parts: (1) A heater, in which all the molecules of the water to be purified are kept for an exact length of time at the temperature of sterilization; and (2) two temperature recuperators.

The heater is composed of two very distinct parts, viz., (1) of a small steam generator that is charged and regulated automatically, and (2) of a spiral coil formed integrally with the boiler and consisting of a series of horizontal tubes arranged one above the other, and connected by intercommunicating boxes.

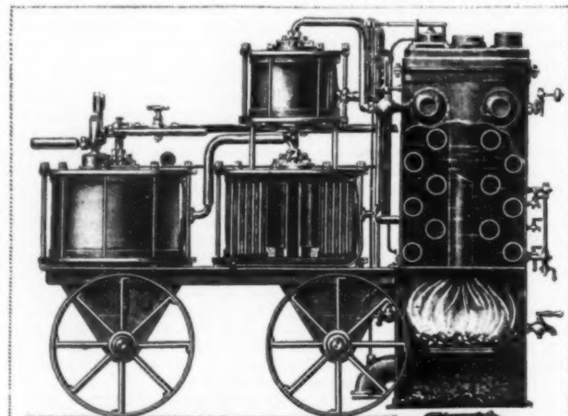


Fig. 2.—SECTIONAL VIEW OF THE APPARATUS.

The water to be sterilized enters the lower part of the coil and traverses it from end to end. The arrangements of this part bring the water to such a state of division that all the molecules are certainly touched by the heat.

The two exchangers or recuperators are identical and composed of metal plates wound concentrically in such a way as to leave perfectly tight spaces between them 16 inches in height and .2 of an inch in width. These spaces form two distinct conduits, one for the cold water going to the heater, and the other for the warm water coming from the spiral coil in an opposite direction. In this way two contrary currents circulate contiguously through the whole extent of the conduits. It is in the circuit through the exchangers that is produced the progressive exchange of temperature between the water to be heated and that which comes from the spiral coil. The exchange surface has an area of no less than 1,075 square feet. Considering the limited size of the apparatus, this is a very remarkable result.

Upon making its exit from the worm, the sterilized water first traverses a third recuperator-exchanger, the object of which is to retain the calcareous deposits that might not be wholly collected in the tubes of the heater.

The accompanying Fig. 2 indicates the course of the water in the parts of the apparatus exclusive of the third exchanger just mentioned. The path of the cold water to be sterilized is indicated in gray, and that of the warm water coming from the spiral coil is shown in white.

During the entire time of its heating, the water always circulates in a closed vessel, and can therefore lose but a very small portion of the gas that it holds in solution. For the same reason, the proportion of its mineral salts does not change. It hence preserves all its organoleptic qualities, and does not, although absolutely sterilized, present the inconveniences possessed by water boiled in the open air. Finally, the water coming from the apparatus is cold and can be drunk at once.—Translated for the Scientific American Supplement from La Nature.

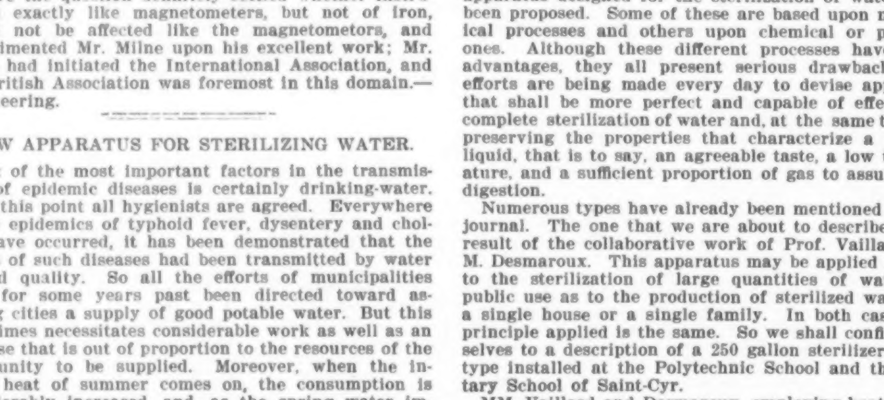


Fig. 1.—GENERAL VIEW OF THE VAILLARD-DESMAROUX APPARATUS FOR STERILIZING WATER.

ANIMAL THERMOSTAT.

At the British Association meeting a paper from Lord Kelvin, entitled "Animal Thermostat," was read, in his absence, by Prof. Purser.

A thermostat, Lord Kelvin said, was an apparatus or instrument for automatically maintaining a constant temperature in a space, or a piece of solid or fluid matter, with varying temperatures in the surrounding matter. Where and of what character was the thermostat by which the temperature of the human body was kept at 98.4 deg. Fahr.? It had long been known that the source of heat drawn upon by this thermostat was the combination of food with oxygen, when the surrounding temperature was below that of the body. Magnus's discovery still, he believed, held good, that the place of the combination was chiefly in minute tubes through which blood circulated through all parts of the body, and not mainly in the place where the furnace was stoked by the introduction of food, or in the lungs, where oxygen was absorbed into the blood. It was possible, however, that the controlling mechanism by which

the temperature was kept down to 98.4 deg. might be in the central parts about or in the pumping station (the heart), but it might seem more probable that it was directly effective in the small blood vessels in which the combination of oxygen with food took place. But how did the thermostat act when the surrounding temperature was anything above 98.4 deg. and the atmosphere saturated with moisture so that perspiration could not evaporate from the surface? If the breath went out at the temperature of the body, and contained carbonic acid gas, what became of the heat of combustion of the carbon thus taken from the food? It must somehow be carried out by the breath, because heat was being conducted in, from without, across the skin all over the body, and the food and drink we might suppose to be at the surrounding temperature when taken into the body. There was in the breath not only carbonic acid, but also vapor of water, due to combination of the inhaled oxygen with hydrogen of the food. Hence, to carry off the heat of combustion there must be more vapor of water in the breath than that due to internal combination of hydrogen with oxygen. That was to say, the thermostat must direct evaporation from the lungs of the water drunk, or of the watery parts of the food, sufficient to carry off all the heat of combustion, and all the heat conducted in across the skin. Much was wanted in the way of experiment and observation to test the temperature of healthy persons living in a thoroughly moist atmosphere at temperatures considerably above 98.4 deg., and to find how much, if at all, it was above 98.4 deg. Experiments might also, safely, he believed, be tried on healthy persons by keeping them for considerable times in baths at 106 deg. Fahr., with the surrounding atmosphere at the same temperature, and thoroughly saturated with vapor of water.

COMPENSATION FOR THE WEAKENING OF PERMANENT MAGNETS.

PERMANENT magnets of measuring instruments are used either as a controlling force (as in the Deprez type of instrument represented in Fig. 1) or as a deflecting force (as in the well-known Deprez-d'Arsonval form of instrument, illustrated in Fig. 2). The weakening or time variation of their field gives great trouble to manufacturers and users of instruments, as it is by no means an easy matter to make it negligible.

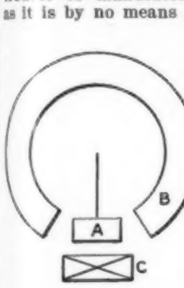


FIG. 1.—FIRST TYPE OF INSTRUMENT. A, Moving iron; B, permanent magnet; C, actuating coil.

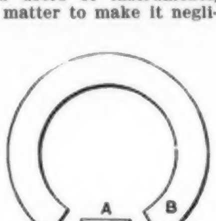


FIG. 2.—SECOND TYPE OF INSTRUMENT. A, Moving coil; B, permanent magnet.

The result is a proportional weakening of the controlling force in the first type of meter, and a proportional weakening of the deflecting force in the second type, so that the deflection of the needle for a given current is increased in the former and decreased in the latter type of instrument.

A new type of instrument has been devised by M. Weiss, and has now been constructed in France by M. Japy, with a view to eliminating this error. This new compensated instrument (Fig. 3) was presented by M. Weiss before the Société Internationale des Electriciens at the meeting on April 9, 1902.

It is a modification of the Deprez-d'Arsonval type, Fig. 2, being essentially composed of a moving coil, *b*, actuated by the field of a permanent magnet, NS. The controlling force, however, is not due to the elasticity of suspension wires, as in the d'Arsonval instrument; this elastic force is made as low as possible, and the

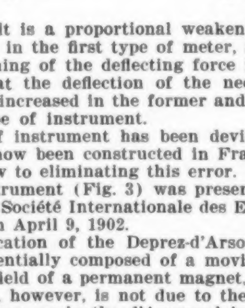


FIG. 3.—COMPENSATED INSTRUMENT.

controlling force is obtained by means of a small piece of soft iron suspended in the axis of the moving coil. The greater part of the controlling force results from the field of the magnet, NS, acting on the induced magnetism of iron M. A weakening of the magnet NS will thus decrease the controlling force at the same time as the deflection force.

The time variation of the magnet will, therefore, have no effect if a proper relation exists between the dimensions and magnetic density of the magnet, NS, the iron piece, *M*, and the elasticity of the suspension wires. The time variation in these latter will have no influence either, since their action has now been made practically negligible. M. Weiss states that as much as 20 per cent variation in magnet strength does not result in any change in the calibration curve. An aluminium spool carries the coil, and this damps the oscillations of the coil. Moreover, the light weight, when pivoted on jewels, allows the apparatus to be placed in any position without any sticking or perceptible friction. Thermic variations are avoided by the use of manganin wire.—The Electrician.

HOW TO REMOVE THE INNER TUBE OF A DOUBLE-TUBE AUTOMOBILE TIRE.

THE following explanation of the method pursued in taking out a punctured inner tube of a double-tube automobile tire will doubtless be of interest to many of our readers.

If the tire has not been taken off for some time, the

FIG. 1. FIG. 2.

flange of the tire will generally stick to the rim of the wheel. The flange must first be loosened by pushing against the side of the tire with the left hand and prying with the lever, which is held in the right. Selecting a place between two lugs and away from the valve, the top of the tire should be seized with the left hand and its side be pushed away from the edge of the rim by the thumb and palm of the hand. (If more force is needed, try pushing with the elbow.) At the same time, force the lever between the flange of the tire and the edge of the rim, as shown in Fig. 1, lower it to a horizontal position, and push it in about an inch under the flange. **(See Fig. 2.)** The next

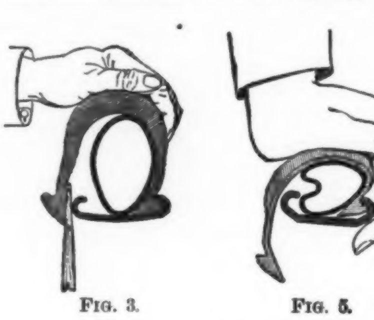


FIG. 3. FIG. 5.

move is to lower the outer end of the lever and at the same time raise with the left hand the side of the tire so that the point of the flange will turn on the lever and assume the position shown in Fig. 3. If the point of the flange does not easily assume this position, but remains in that shown in Fig. 4, while lowering and withdrawing the lever, work it back and forth slightly to the left and right. The back-and-forth movement will facilitate the turning of the flange. It is very difficult to get the flange out if it sticks in the position shown in Fig. 4, and some little skill is required to accomplish it.

If the tire is of the light voiturette type, it can, per-

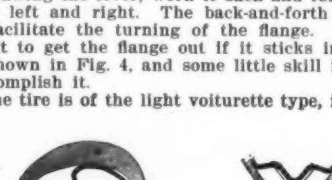


FIG. 4. FIG. 6.

haps, be crowded to one side sufficiently to slip the lever under the point of the flange, as shown in Fig. 7, which greatly simplifies the operation.

When a part of the flange has once slipped by the rim, if the tire is flexible from having been removed several times, it can be handled as follows with one lever, otherwise two levers will have to be used.

Standing on the left of the wheel, leaving the lever in the position shown in Fig. 3, grasp the tire in both hands, being careful not to cut in it with the finger nails, and draw it toward you, going along it with the left hand, with which you push back and raise the outer tube so as to facilitate the slipping out of the

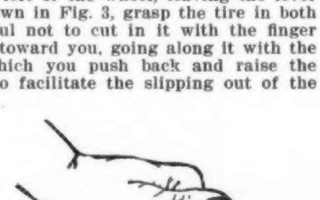


FIG. 7.

flange. Upon reaching a fastening lug, be careful to raise the stem of the latter and place it in the position shown in Fig. 6.

It will be noticed that the flange has a tendency to again slip over the edge of the rim and resume its normal position. To stop its doing this, it is necessary, when a short length of the flange has been slipped out, to draw it toward you and press down on it, as shown in Fig. 5, thus causing the flange to hang down and hide the rim.

The body of the valve is drawn through the rim after the parts of it that will not pass through have been removed and laid one side. In taking out the inner tube, draw the tire carefully to one side, beginning opposite the valve, and working around to it. Care must be taken not to tear the inner tube where the valve is fastened in. If it adheres to the outer tube at any point, pull it away very carefully. If it is a large tire, it will be necessary to hold the outer tube with the lever while taking out the valve.

SCIENCE AND LITERATURE.*

ON what subject ought one to speak at the beginning of the session of a College of Science which is also a School of Applied Science, speaking, not only to one's colleagues, but to new and old students who differ from one another in character, training, social position and attainments more than the students of any other college probably in the world? This college has three functions. It gives the highest possible instruction in mathematics and natural philosophy and in all the natural sciences. It gives technical instruction to mining, metallurgical and mechanical engineers. It gives pedagogic training to teachers of all subjects taught at the college. The presence of Sir Arthur Rücker, Principal of London University, reminds me of a fourth function which has recently been added, namely, the preparation of students to pass university examinations.

I am strongly of the opinion that every engineer—that is, every man whose business it is to apply any of the physical sciences—ought to have a more or less thorough training as a mechanical and electrical engineer. In the address which I had the honor to deliver three weeks ago as president of the Engineering Section of the British Association, I tried to show that only an exceptional student can obtain such training unless he spends much time in mechanical or electrical engineering laboratories such as I there described. For many years, from long before I came to Kensington, the mechanics course here has been one in mechanical engineering as well as in mechanical philosophy. My anxiety to own a laboratory has met with the utmost sympathy from the higher authorities and the council of the college. I may say that we are all as anxious that students should work with electric generators and motors and other electric-power plant apparatus as with steam and gas engines, with water turbines and pumps. I know that some of you blame me because I can give none of this necessary instruction, and sometimes, perhaps, I blame others for not affording me facilities. The curriculum at this college was arranged a great many years ago, when people aimed only at the training of the exceptionally clever student, and, indeed, before any electrical appliance was used by miners or metallurgists; before the time when a mine became filled with mechanical contrivances. Every mining or metallurgical or other technical school now established in any part of the world gives this sort of training to the students, yet we are unable to give it. The authorities of this College are in sympathy with you and with me, and would help us to this necessary laboratory work and greater space and other facilities for instruction in my division if they possibly could. Parenthetically, I may observe that, in so far as applied mechanics and engineering theory are concerned, the courses of study here will enable any willing student to obtain the highest engineering degree of the University of London.

Some of you are extremely well read in scientific text-books, having passed most severe examinations in pure and applied science. And not mere text-books, but real scientific books have been studied by many of you; for I know that some of you have dipped into Larmor's book on the ether, and have read Thomson and Tait and Maxwell and Rayleigh. Not only have you this wonderful knowledge in science, but you have been earning your own living and you have developed an instinct for taking advantage of chances, of fending for yourselves, of making other people do what you ask, that is perfectly marvelous. Some of you remind me of great fir-trees that I saw in Norway this summer, spreading their roots over a rocky soil, gaining sustenance where no other kind of tree could exist. One power more developed than another is that of passing examinations. Nobody who is without the experience of an examiner of candidates from the evening science classes can comprehend your power of getting marks from a careless examiner for answers to questions on subjects about which your knowledge is limited. There is hardly any town in the British Islands from which our scholars—I suppose that quite a hundred scholars are here—have not come, each picked from many hundreds or thousands, each the recipient of great honor and a valuable scholarship, and your townspeople and your old companions are keeping their eyes on you, wondering whether or not it is a great man of the future that has been sent up to us. And now for the other side. You know much of what has been done, but have you the power to discover, to add to the world's knowledge? Your knowledge has been derived from books and lectures; you have now to learn that a week in the laboratory, during which you seem to crawl, during which for examination purposes you do less than in reading ten lines of a text-book, is really of more value to your scientific education than a month's hard reading. This is almost unbelievable to you who are such adepts in passing examinations; yet it is quite true. Lectures and lessons have spoon-fed you until now; lectures and lessons will in future teach you to feed yourselves.

Again, many of you think it is not only a waste of time, but a positive sin, to read novels and poetry and general literature, to cultivate in any way the imagination, to take an interest in painting or sculpture or music. You have yet to learn that although parrots and other imitative animals can get on without imagination, there is no such thing in existence as an unimaginative scientific man. That you have some imagination and individuality is evidenced by your differentiation from all other students of science classes; but have you these well developed, and have you those other qualities which are absolutely neces-

* Abridged from the inaugural address delivered at the Royal College of Science (with which is incorporated the Royal School of Mines), London, by Prof. John Perry, M.E., D.Sc., LL.D., F.R.S., Professor of Mechanics and Mathematics, on October 2.

sary for the success of a scientific worker? Imagination is far and away the most important; but there are also judgment and common sense, and the love of truth and the power of self-sacrifice, which seem always to accompany the pursuit of science. Are you fond of reading? Do you know how to use books? Can you explain with decent sketches what you observe and know? Mere learning is a poor thing, but fondness for reading leads to the greatest possible development of all one's intellectual and emotional faculties. Fondness for reading will come to you if your companions are fond of reading. English and English subjects are badly taught in school; hardly anybody anywhere seems able to teach them; one's own reading and discussion with friends are far better for one's education than any course of lectures. However limited your past education may have been, whatever defects some hypercritical learned man may see in the school system under which you have been brought up, starting from your present conditions, if you are fond of reading and have common sense, there is nothing to prevent your becoming men of the finest kind of liberal education. But you must exert your common sense and try to distinguish clearly what is essential from what is unessential in education. English literature is equal to, if not greater than, any literature of any people that exists now or has ever been. The language of our great Empire is enough for any man who is not specially fond of language study. If you love to study foreign or dead languages, do so; but if you are not so inclined you will be acting foolishly to waste your time over them.

The average man cannot be much hurt intellectually by anything he does, but the higher intellect is, I think, easily hurt, and I know of several men who had genius, real genius, whose intellects have been permanently dwarfed by a six months' course of classics pursued with the base object—degrading to classics and to themselves—of becoming able to pass an examination. There are some kinds of moral degradation which are final; the holy of holies has been desecrated once for all. My language about this matter will not probably be understood by more than a few of my hearers, but if there is even one who understands, my message is very important. If such one is here I would warn him that there are certain prices too large to pay for examination success. I object very much to those examination systems in which certain things are compulsory. Of course, we cannot get rid of all compulsory things. English and English subjects must be compulsory on English students. But I do say that the list of compulsory things should be made as small as possible. I am told that a knowledge of the German language must be made compulsory for chemists and biologists. I am sorry to think that this may be so. But inasmuch as the men who tell me this say that it is the case also for physicists and mathematicians and engineers, I venture to doubt the necessity for compulsion in any case whatsoever. I am perfectly certain that in these days of much publication of translations and abstracts of foreign scientific papers, no kind of physicist or engineer needs French or German or any foreign language so much that it is *imperative* on him to make a study of it. The men who insist on the study of a language other than English do not seem to know how difficult such a study is for some students. Time will not allow me to do it here, but I hope some time to have a chance of pricking this compulsory foreign language bubble which everybody is cherishing at the present time without really thinking about its intrinsic value. How often have I heard common men say that they abhor translations; that the style and real flavor of an author are only to be had in the original. I notice that such men read very little. I doubt if the average educated man ever does get that kind of appreciation of a foreign author which the author's educated countrymen get so easily. I have met all sorts of men in my life, and I have never seen reason to alter the opinion of my young days that a lover of reading can get immense satisfaction from a translation—whether it is from Greek or Latin, French or German, Spanish or Italian, Russian, Scandinavian or Hebrew; whether it is Omar Khayyam or the Rig Veda, the Talmud or the Koran, or the Bible. To the lover of English all literature is open. The man who insists on reading "the original" seems to me like a tethered cow, such as we see in Jersey; it crops the grass very closely, but surely it must sometimes sigh for a little more freedom and a more extensive range of grazing! If you had finished your course here I would say to you that we are all getting far too learned in natural science. We read far too many of the latest papers. Some of the greatest scientific workers of our times—men who are constantly advancing the boundaries of knowledge—read almost nothing of what other men do. I wish I had time to give you some interesting, and indeed absurd, examples of this. The average scientific man merely casts his eyes over the twenty or thirty scientific periodicals that every man buys every month; he does not even read that valuable periodical "Science Abstracts," or those abstracts of chemical papers published so voluminously, for he has no time. The men who read everything that is written in scientific journals, not merely in England and America, but also in Germany and France, seem to me to have no time to do anything else; they have no time for scientific work of their own. Indeed, they know so much that a simple investigation such as they might begin upon their own account seems insignificant to them and quite unworthy of the time that they would have to spend upon it. I ask only that in matters like this of foreign languages and so much reading of scientific papers you should really judge for yourselves. In these days you can recognize the manufactured men of science by their taking up a notion without thinking about it, by their inclination to follow a leader as a flock of sheep follows the bell-wether, a phenomenon studied by a famous philosopher named Sydney Ortheris.

When the Prince Consort tried to impress upon this nation those ideas of training in science and art which, if they had been attended to, would have kept us in the front of industrial progress, there was one of his ideas which took root, and which has given rise to the work of the Science and Art Department. I know the faults of the department as well as anybody, but all my life I have been pointing out its enormous services to the country. No other country in the world has anything to compare with it. When I think of our industrial supremacy before 1870, and how during thirty years some of us have been vainly warning a careless people that the combination of wisdom and knowledge which we call science, neglected in the education of all well-to-do people, would lead other nations to the capture of our industries; when I think of the utter failure of our higher educational authorities to recognize facts, I bless the Science and Art Department. For more than forty years, in towns remote from universities, it has been possible for the poorest apprentice or workman to get instruction in natural science. These science and art classes were open to the very poorest. Until lately there were no other classes open to rich, clever students. It is astonishing to me that men should be ignorant of the fact that it is the Science and Art Department which has so far saved our industries. I can speak with knowledge of the engineering industries. Of the many hundreds of thousands of pupils who have successfully passed our examinations, a very large proportion, by the combination of their scientific knowledge or scientific habits of thought with practical workshop knowledge and through their energy, became foremen and managers, and in many cases owners, of works. I need not dwell on the fact that every year since 1869 many Whitworth scholars have been sent out into the industrial world, and I affirm of my own knowledge that these men have become such captains of industry as no other country in the world has at its command.

If only our capitalists had even the most elementary technical training such as is suitable for capitalists, the men educated by the Science and Art Department would alone have enabled them to retain that industrial supremacy the loss of which is being bewailed day by day in the newspapers. Many of our best men are making bricks without straw. They discover, they invent, they project improvements. But if the owner of the works, the son or grandson of the creator of an industry, if all the directors of a company, with however scientific a manager, are quite ignorant of those natural science principles on which the industry is based, if they cannot distinguish between good and evil, there is nothing for the industry except to go upon lines that get more and more old-fashioned until the works stop through inanition. And yet I have heard of cases in which old science students, in spite of heart-breaking failures to interest their superiors, have by dogged persistence maintained works as paying concerns, in spite of competition from American and German and Swiss strategists of the best polytechnic training.

Many of the most successful students hide the source to which they owe their scientific training, because the science class fees are small; the classes are open to the poorest students, and in this country caste feeling so predominates that no man likes to have it thought that he comes of poor parents or that he ever attended a class to which poor students were admitted. If all the successful old Science and Art students comprehended how much harm is being done just now by their careful concealment of the fact that the Science and Art Department used to be, and in many places still is, the only agency through which a scientific training could be given in this country; if they knew of the development which has been going on for some years in the functions of this department; if they knew the importance to the country of a general recognition of the services of the department, they would, I am sure, refrain from hiding their enormous obligations to it. No government department has had so much intelligent criticism, because the only people who know about it are its own students, and they have by it been brought up in an atmosphere of scientific criticism.

And here are you students—about half of you—the picked men of these science classes, caught in our net, the net that Huxley spoke of, selected from thousands of students who are themselves select, selected that we may train most of you to be leaders of scientific thought or great appliers of science, or great teachers of science! There is the idea that for the good of the country our net has caught in one of you the young man most likely to repay cultivation, and I cannot too often repeat that it is not for your sake that this is done. If one of you happens to be a potential Faraday, however poor he may be, and so far as I can see he is just as likely to be poor as to be rich, it is our duty to try to discover him and give him chances of development. We are supposed to give you enough money to live upon; we ask no fees from you; we set you as men whom the King delighteth to honor, side by side with the most promising fee-paying students—men from our public schools, men taught to admire what you have done in the past, encouraged to think you men of promise—and we ask you to develop those exceptional faculties which to you are your own, but which we believe to be national assets.

I will conclude this address by bringing another and much more important problem before your consideration. The matriculation examination of a teaching university has this meaning only—that it is inadvisable to admit men who are obviously unfit to benefit by the instruction given in the university. When in mediæval Europe all university lectures were given in the one universal language, Latin; when men from all nations came to hear the same lectures, it was evident that no man ought to be admitted who had not enough Latin to be able to comprehend the lectures. At present in Glasgow it is assumed that everybody has had the usual school training, and the only matriculation is in signing one's name in a book. Hitherto at this college men who have passed certain examinations in elementary natural science are thought to be fit and proper students, and of course you scholars who have all passed rather difficult examinations in natural science are admitted without question. I am glad to think that every student admitted to this college does always seem capable of benefiting by our instruction; but if you consider what our object is, the education of true scientific men, you will see that there is something much higher than is attempted elsewhere.

Merely to be able to benefit by the instruction, that is a small thing. Men who come here with valuable scholarships are expected, not merely to benefit, but to benefit in a very exceptional way. They are supposed to develop to the very utmost their obvious scientific ability. To test for this likelihood of development in even the roughest way is evidently difficult. Even to apply any test outside the old limits seems difficult, because of the peculiar circumstances under which you are selected for scholarships. In more than half your cases you are not aware beforehand that you have a chance of being selected. You joined science classes merely to obtain a kind of knowledge which would be useful in your daily work. Your prospects were those of a workshop with a slow rise to foremanship. Your spare time was meager; it was stolen at enormous sacrifice from family duty and from those pursuits which make a man popular with his fellow workers; the study of language and literature was comparatively unimportant to you, and you were suddenly told that your scientific talents were such that you were selected for the higher life, the life of the seeker after truth; of the man of brains rather than muscle. In seven cases out of ten, it was quite impossible for you to prepare yourselves for any examination in language or literature in the two months before entering this college. I wish I saw clearly what ought to be done. You are valuable material, and if you come here without that training in your own language, that love of reading which leads to the power to use books and the knowledge of all subjects derivable from books, I am quite sure that you are greatly wasted. I have a solution of this problem, but I am not sure that it is the best solution, and therefore I leave the problem for you yourselves to consider.

TRADE NOTES AND RECIPES.

How to Make Castings of Insects.—The Hindoos, from time immemorial, have excelled all other peoples in making metallic castings of delicate and exceedingly fragile objects. According to a recent writer the following is the process employed by them in making the molds for this kind of work: The object—a dead beetle, for example—is first arranged in a natural position, and the feet are connected with an oval rim of wax. It is then fixed in the center of a paper or wooden box by means of pieces of fine wire, so that it is perfectly free, and thicker wires are run from the sides of the box to the object, which subsequently serve to form air channels in the mold by their removal. A wooden stick tapering toward the bottom is placed upon the back of the insect to produce a runner for casting. The box is then filled up with a paste with 3 parts of plaster of paris and 1 of brick dust, made up with a solution of alum and sal ammoniac. It is also well first to brush the object with this paste to prevent the formation of air bubbles. After the mold thus formed has set, the object is removed from the interior by first reducing it to ashes. It is, therefore, allowed to dry, very slowly at first, by leaving in the shade at a normal temperature (as in India this is much higher than in our zone, it will be necessary to place the mold in a moderately warm place), and afterward heating gradually to a red heat. This incinerates the object, and melts the waxen base upon which it is placed. The latter escapes, and is burned as it does so, and the object, reduced to fine ashes, is removed through the wire holes as suggested above. The casting is then made in the ordinary manner.—Nat. Drug.

Stove Polish.—Many stoves need re-blacking through the winter months, and the pharmacist may be able to furnish some of the polish required. Graphite (often misnamed black-lead) is the foundation ingredient in a stove polish. Lampblack is frequently added to deepen the color, but the latter form of carbon is of course more readily burned off than the former.

The powder variety of stove polish is merely purified and ground graphite with or without the addition of lampblack. It is applied to the stove by being first mixed with a little water.

The paste is made by the addition of glycerin or paraffin oil to the powder.

The following formula gives a liquid stove blacking:

Graphite in fine powder	1 pound
Lampblack	1 ounce
Rosin	4 ounces
Turpentine	1 gallon

This form may be esteemed a convenience by some, but the rosin will, of course, give rise to some disagreeable odor on first heating the stove, after the liquid is applied.

The mixture must be kept well shaken while in use, and must not be applied when there is a fire or light near on account of the inflammability of the vapor.

The solid cakes of polish are said to be made by subjecting the powdered graphite, mixed with spirit of turpentine, to great pressure. It has to be reduced to powder and mixed with water before being applied.

Any of them has to be well rubbed with a brush after application to give a handsome finish.—Drug. Cir. and Chem. Gaz.

Insolubility of Bleached Shellac.—Bleached shellac is said to be invariably more difficult to dissolve than the unbleached. According to W. E. Wall this difficulty increases with the age of the shellac; the older it is, the more difficult it is to dissolve it and it finally becomes insoluble, and after years of exposure to the action of air and light, it will not even melt.

We do not know any method of restoring shellac, so changed to its original condition as to solubility.—Drug. Cir. and Chem. Gaz.

Removal of Dirt from Paraffin.—It is possible that filtration through felt may remove the particles of foreign matter from your paraffin; it may be necessary to use a layer of fine sand or of infusorial earth. If discolored by any soluble matter try freshly heated animal charcoal. To keep the paraffin fluid if a large quantity is to be handled a jacketed funnel will be required, either steam or hot water being kept in circulation in the jacket.—Drug. Cir. and Chem. Gaz.

Peach Kernels as a Clearer for Muddy Water.—A Dutch hotel keeper in the Transvaal clarifies the turbid water of the district in the following way: Half a dozen dried peach kernels are slightly cracked and thrown into a large butt of water. In an hour or two the muddiest water will be found beautifully clear.—Nat. Drug.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Demand for Fruit-Handling Apparatus in New Zealand.—Messrs. G. H. Grapes & Co., horticultural merchants of Paraparaumu, Wellington, New Zealand, write to the Bureau of Foreign Commerce:

"I would feel obliged if you would kindly place me in touch with manufacturers of woodworking machinery for fruit cases and boxes for packing glass, especially those making a suitable description of reciprocating three-bladed gang-saw machines; also with makers of the apparatus necessary for the equipment of a small fruit-preserving plant (suitable for turning out 1,000 to 10,000 two-pound glass jars of jam per diem) and for jelly making and fruit bottling; also with makers of first-class fruit-grading machinery on the automatic principle—the above to be worked by a 12 horse power engine. I would be glad to hear from makers of such engines and boilers. I already use many American tools and machinery, and highly appreciate their labor-saving qualities. I am practically an American in my thoughts and methods.

"We have a wide field here for agricultural machinery, and I feel sure if you draw the attention of your manufacturers to this rapidly advancing colony of the British Empire, you will be conferring a benefit upon all."

Stationery Goods in Canada.—A Canadian dealer draws his supplies from many sources. Proximity to the United States is greatly in favor of the stationery manufacturers of our country, many of whom have taken advantage of this market to the fullest extent and push their goods ahead of those of all other countries; but the stationery imports from Great Britain and other Old World countries are considerable and are growing rapidly. Imported goods are generally chosen in Canada in preference to those of home manufacture.

Writing Paper.—Much of the paper for manufacturing fine writing stationery is of United States origin. Our market commends itself to the Canadian buyer, for the reason that the goods can be shipped in any desired quantity and in quick time; and in novelties, the United States is far ahead of any other country. Travelers from our mills visit this market nearly every month and thus keep in close touch with the jobbers, while a yearly call is all that British representatives pay. Of course, much paper of ordinary class in bond, parchment, and vellum, is made in Canada. Fancy tints also are made to some extent, but most of these come from the United States.

Papeteries.—In papeteries, the English houses stick mainly to staple sizes. The quality of the British papeteries is said to be finer than the American, but they are not put up so tastefully. The British goods are cheaper than the American. A few novelties in papeteries come from France. These are in flaring colors, and are not in great demand. Nearly all black-bordered note paper comes from Great Britain.

Blotting Paper.—In blotting and typewriting papers the United States is in the lead. The thick blotting-paper, which formerly came from England and Scotland, now comes from Virginia. In thin blotting paper, the trade is still in favor of the old country. Blotting paper, with one side glazed for advertising purposes, comes wholly from the United States.

Artists' Paper.—Great Britain is far ahead of other countries in the Canadian market in drawing, water color, and all artists' papers. The American mills are, however, commencing to make these, and are threatening competition with British goods.

Tissues.—The best imported tissue papers come from England. The cheaper goods are from Belgium, and a few from the United States. Crape papers come from American and English makers.

Inks.—Imported ink comes from England and the United States, and a little from France. The English inks are the best known and have probably an advantage on the market. The preferential tariff places them on an equality, as far as price goes, with the United States goods. Most of the French inks go to Quebec. Ink powders are growing in popularity, chiefly because importers do not care to pay duty on so much water, when the ink is shipped in liquid form. These come from Great Britain and the United States.

Mucilage.—Mucilage is imported from England and the United States. The white paste is nearly all American.

Pens.—Steel pens come to Canada mostly from Birmingham. Some large United States manufacturers sell a number to Canada, and the pens made especially for the vertical writing taught in the schools are American.

Sealing Wax.—The best sealing wax comes from England. Some is brought from the United States, but it is of a cheap variety and not a great deal is used here.

Rubbers.—Imported rubber bands are all from the United States. A cheap quality was formerly made in Canada, and for a long time those of home manufacture have had this reputation. Those now made here, however, are quite equal to any imported goods.

Pencils.—The best lead pencils are, of course, from Germany. All good drawing pencils come from that country, which imports the pine wood from the United States, makes the pencils, and then is able to lay them down in Canadian markets in better quality and at a lower figure than home-made goods. The United States pencil makers are mostly interested in rubber-tipped and fancy designed varieties.

Erasers.—The United States makes the best rubber erasers; but in this line Canadian manufacturers are offering keen competition.

Fancy Goods.—Fancy ink bottles, paper weights, and other goods of the kind come from Austria and France. Many novelties in the stationer's trade, such as fancy trays, match safes, etc., are of American make; but Austria, France, and Germany have the bulk of the novelty trade.

Globes, etc.—Map globes are made in the United States. Blackboard brushes, slates, and numeral frames are other school accessories in which American firms do nearly all the trade in Canada. Silver and gold pencils and other stationers' jewelry are mostly from England, though the United States is rapidly coming to the front.

Lanterns, etc.—What we call Chinese lanterns are made in Germany. The Japanese lanterns, however, are really from Japan. Wicker wastepaper baskets, slate pencils, artists' brushes, damping brushes, and the cheaper seals and stamps are of German make.

Bags.—In school bags, the canvas ones are from England and Germany. All the leather bags are of Canadian make. Other countries have not been able to compete in this line.

Instruments.—Mathematical instruments of the best kind for school and professional use are made in France. Compasses are brought from England and the United States, also, but they are said to be not as good as the French makes.

Cards.—All the playing cards imported are of the best class. The duty of 6 cents per pack keeps out the cheap goods. Most of the cards come from the United States. High-class Christmas cards are sent from England; much of the work on them is done in Germany. The best visiting cards are British.

Games.—Chessmen, checkers, dominoes, cribbage boards, whist markers, etc., are brought from Germany. Some American checkers and dominoes are beginning to take the place of the German goods; but on the whole, Germany is the origin of the great bulk of these goods.

Miscellaneous.—Germany, England, France, and Italy supply Canada with rubber balls. The best come from England, and the fancy balls mostly from Germany.

Most of the school crayons and chalk come from the United States. Oil crayons are being used more than chalk now, and it is likely they will soon displace it altogether.

Files, bill stickers, stamping pads, and wire waste-paper and desk baskets are American. Paper fasteners come from England. The porcelain sponge cups are made in Great Britain, but the glass ones are made in both that country and the United States.

Ebony and ebonite rulers are mostly from Great Britain; the other rulers from the United States.

Opera glasses and magnifying glasses of the best kind come from France, though some of the latter are of English make.

France and Germany export to this country stamp, photo, and scrap albums. A few are made in Canada.

Cotton flags are all Canadian, but the best bunting and silk flags are imported from England and France.

Fancy photo frames, in brass and other metals, as well as in cardboard and enamel, are mostly of German make. A few are American.

All celluloid goods come from New York. Zylonite, and imitation, is English.

Letter presses are mainly from the United States and letter balances from Great Britain.

Key rings and chains, gold and silver paper, and telescopes are nearly all from France. Penholders are brought from the United States and Germany.

Leather Goods.—Most of the leather goods used are manufactured in Canada. The leather is imported already tanned and prepared to be cut up into purses, belts, valises, etc. Germany, England, and the United States are the chief exporters in this line to Canada. Morocco or goatskins, real Russian and seal skins, for purses, wallets, etc., come from Great Britain. Some seal skin is from Germany. Alligator, already tanned and glazed, comes principally from Florida. Russia leather is wholly an English product. The Americans have a close imitation of it, but most of the goods are from the old country. Walrus, monkey skin, sea lion, hippopotamus, etc., are generally made of seal, a different grain on them being their only title to the fancy names. Snake and lizard skins wear out so quickly that very few are used, and they are expensive. They come from England and the United States. Calfskins are brought from the United States, Germany, and England.

Canadian manufacturers use their own sheepskins much more than imported goods. Those that do come in are from Germany, England, and the United States. The rough sheepskin used for blank books is nearly all Canadian.

The metal fittings and frames for stationers' leather goods are all imported from England, France, and Germany.—John L. Bittinger, Consul-General at Montreal.

Automobiles in Australasia.—

Mr. O. H. Baker, consul at Sydney, says:

NEW SOUTH WALES.

In and about Sydney, there are hilly and rough roads. In the most populous parts of the city, the streets are narrow. Steam, electric, and cable trams, heavily loaded traffic wagons, and private vehicles contest for passageway, so that the pleasure of automobile riding in these parts is much lessened.

Machines in Use.—In the suburbs, the roads are not inviting, yet there is quite a number of these machines in use here—14 of French make, 1 German, 4 Winton (American), and 1 locomobile (American). One of these is propelled by steam, and 19 by gasoline.

There are now on hand for sale 12 steam, 5 electric, and 5 gasoline (American).

There are no automobiles manufactured, so far as I know, in Australia, nor is there a great demand for them at present prices.

Some prejudice has been excited against the motor car in Sydney, from the fact that one style is noisy, frightening horses as it passes.

It is suggested that the American manufacturer, in aiming at the least weight possible, has largely sacrificed the strength necessary to stand the strain on Australian roads. This is especially true of the axle, spring, and frame. There should be some improvement devised, by which the machine could be depended on to make the journey for which it is charged, without filling the air with unpleasant odors or making so much noise.

The Woods' electric vehicles have been given a fair trial here, but owing to the scarcity of charging facilities, have proven a failure.

Style Demanded.—There would, I think, be a demand for the following:

1. A strong hill climber, capable of standing the strain on rough roads, with capacity for three or four persons.

2. A delivery wagon, with and without canopy, of from one-half to 1 ton capacity.

3. A vehicle that would carry five persons and 4 or 5 cwts. of mail bags over rough, hilly roads, the under gear being as high from the roads as possible.

Tariff and Laws.—The duty on automobiles throughout Australia is 20 per cent ad valorem. This may, however, be revised, as the Senate has yet to pass upon that part of the tariff.

There are no State, county, or city laws of interest to automobile manufacturers and users.

Manufacturers, dealers, or users of automobiles are not required to take out a license or to register.

NEW ZEALAND.

Vice-Consul L. A. Bachelder, of Auckland, reports:

Tariff.—The customs duty on automobiles is 20 per cent ad valorem, and the same rate is charged on finished or partly finished parts of same, including weldless steel tubing cut to short lengths.

The engines, if packed separately from the carriage, are duty free; also rubber tires, pneumatic tires, outside covers, and inner tubes, rubber and cork handles, drop forgings and stampings, ball bearings, weldless steel tubes in full lengths, rims, forks, and spokes in the rough. During the past year, two machines have been running in Auckland at various times, exhibited by the importers, but no private individuals have so far bought any. One of these is a locomobile, manufactured by the Locomobile Manufacturing Company of the United States. The other is of French make, and was found not powerful enough for the hills and bad roads in North Island. It was finally sold to go to Christ Church, South Island, and according to report it has given good satisfaction there. There appears to be very little demand here for these machines, in part on account of the coast, and also because of the bad condition of the roads and the hilly country. Dealers in a similar line of business say that they would not stock them.

There are, it is estimated, about 20 carriages of this kind running in South Island.

VICTORIA.

Consul-General J. P. Bray writes from Melbourne: The market for automobiles is very limited, the Australian people considering motor cars as only in the experimental stage and not to be depended on for practical purposes. Prices, also, are so high that they will not easily be persuaded to purchase cars to prove the contrary for themselves. There are very few motor cars to be seen here, for the foregoing reasons, although several well-known makes are represented and have been advertised. I feel certain that for some time to come, firms introducing motors will have an uphill task, and they probably will not reap the full benefit of their efforts for years.

Even if prospects were better, the fact must be borne in mind by our manufacturers that there is a duty of 20 per cent on imported motor cars, and stimulated by such an advantage, in addition to the heavy transit charges from the United States to Australia, the local manufacture of them, which has already been commenced by several parties (as yet in a small way), would no doubt increase with the demand.

Automobiles in the Canary Islands.—Consul S. Berliner, of Teneriffe, says:

A company is about to be formed here, styled the "Teneriffe Motor Car Company," the object being to introduce a number of motor cars to ply between the different towns in the island. A car to seat 15 passengers will run between Laguna and Orotava, a distance of 20 miles, and a supplementary car will run between Orotava and Icod, a distance of about 15 miles. The time of both will be so arranged as to connect with the electric tramway now running between Santa Cruz and Laguna.

It is hoped that during the summer another car will be included in the service, to run between Santa Cruz and Guimar, a distance of 20 miles.

The roads are adapted for motor cars; they are well and solidly built.

The motor cars will be furnished by the well-known firm of Paris, MM. Panhard & Levassor, the horse power varying from 7 to 15 and the cost from $2,500 to $3,000.

In my opinion, these cars are heavy and clumsy looking, and I believe an opportunity is here presented for enterprising American firms, for I think there can be little doubt that the service will prove remunerative and will be further extended.

German Opening for Canned and Dried Goods.—The Bureau of Foreign Commerce has received a request from Georg H. C. Dreyer, Hüxter 6, Hamburg, for the addresses of first-class American houses selling dried fruits, canned goods, casings, meats, etc., the German agency for which is desired by Mr. Dreyer. The letter adds:

"Our Mr. Georg Dreyer was for some years with Messrs. Knauth & Co., in Hamburg, the branch house of Messrs. Knauth, Machod & Kuhne, of New York, and knows the trade well in Hamburg and throughout Germany."

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

SELECTED FORMULÆ.

Dentifrice.—

Anise seed	20 parts
Cloves	20 parts
Cassia	20 parts
Oil of peppermint	10 parts
Vanilla	1 part
Alcohol	700 parts
Water	300 parts

—Drug Cir. and Chem. Gaz.

Violet Perfume.—

Extract of cassie	8 ounces
Extract of violet	9 ounces
Extract of rose	6 ounces
Extract of jasmine	2 ounces
Tincture of orris	3¼ ounces
Tincture of storax	1 ounce
Oil of bitter almond	3 minims
Oil of rose	5 minims

—Drug. Cir. and Chem. Gaz.

Aromatic Cachous.—

Oil of peppermint	30 drops
Oil of lemon	20 drops
Oil of neroli	20 drops
Oil of cinnamon	20 drops
Cloves	40 grains
Vanilla	2 drachms
Orris root	2 drachms
Sugar	¾ ounce
Extract of licorice	1¼ ounces
Mucilage of acacia, a sufficient quantity.	

Reduce the solids to powder, add the remaining ingredients, make into a mass, roll out flat, and cut into pieces of suitable size.—Drug. Cir. and Chem. Gaz.

Lavender Bouquet.—

Oil of lavender (Mitcham)	3½ ounces
Spirit of bergamot	1 ounce
Tonka bean	2 ounces
Alcohol	6½ pints

Crush the bean and add to the other ingredients, previously mixed. Allow to stand for a few days, with occasional agitation, then add

Water	1½ pints

After shaking well, put aside for some weeks before filtering.—Drug. Cir. and Chem. Gaz.

Stick Pomade.—

Tallow	500 parts
Ceresin	150 parts
Wax, yellow	50 parts
Resin, light	200 parts
Paraffin oil (thick)	300 parts
Oil of cassia	5 parts
Oil of bergamot	5 parts
Oil of clove	2 parts

—Drug. Cir. and Chem. Gaz.

Crayons for Marking Glass.—

Spermaceti	4 parts
Tallow	3 parts
Wax	2 parts
Bone black	6 parts
Potassium carbonate	1 part

Melt the spermaceti, tallow, and wax together over a slow fire, and when melted stir in, a little at a time, the potassium carbonate and bone black, previously well mixed. Continue the heat for 20 minutes or half an hour, stirring constantly. Finally, withdraw from the source of heat, and let cool down somewhat, under constant stirring, to a temperature of about 180 deg. F.; before, however, the mixture commences to set, pour off into molds and let cool. The latter may be made of bits of glass tubing of convenient diameter and length. After the mixture cools, drive the crayons out by means of a rod that closely fits the diameter of the tubes.—Drug. Cir. and Chem. Gaz.

To Solder Glass to Metals.—First warm the point of the glass where it is to be joined, and by means of a camel's hair pencil paint it slightly with a solution of neutral platinum chloride mixed with oil of chamomile. The oil is allowed to evaporate slowly, and when no more white vapors from the oil appear, the glass is heated to a red glow. This reduces the platinum to a brilliant layer of the metal, which on the cooling of the glass appears to be burned into the surface. This is placed in a copper bath and electrically connected so that the platinum surface is plated with copper. It is then ready for soldering—Drug. Cir. and Chem. Gaz.

White Polish for Wood.—

White lac	1½ pounds
Powdered borax	1 ounce
Alcohol	3 pints

The lac should be thoroughly dried, especially if it has been kept under water, and, in any case, after being crushed, it should be left in a warm place for a few hours, in order to remove every trace of moisture. The crushed lac and borax are then added to the spirit, and the mixture is stirred frequently until solution is effected, after which the polish should be strained through muslin.—Drug. Cir. and Chem. Gaz.

Waterproof Cement for Glass.—

White glue	10 parts
Potassium bichromate	2 parts
Water	100 parts

The glue is dissolved in a portion of the water by the aid of heat, the bichromate in the remainder, and the liquids mixed, the mixing being done in a feebly lighted place, and the mixture is then kept in the dark.

It is applied in feeble light being reliquefied by gentle heat, and the glass, the fractured pieces being tightly clamped together, is then exposed to a strong light for some time. By this exposure the cement becomes insoluble.—Drug. Cir. and Chem. Gaz.

Cement to Withstand Water and Dilute Mineral Acids.—

Burgundy pitch	6 parts
Gutta percha	1 part
Pumice stone, in fine powder	3 parts

Melt the gutta percha very carefully, add the pumice stone, and lastly the pitch, and stir until homogeneous. Use while still hot.—Drug. Cir. and Chem. Gaz.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents and canvassers.

MUNN & CO., Publishers, 361 Broadway, New York.

TABLE OF CONTENTS.